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## Operator DYNA\_TRAN\_MODAL

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### 1 Goal

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To calculate the transitory dynamic response of a system deadened or not in generalized coordinates. Calculation is carried out by modal superposition or under-structuring.

Not-worthless initial conditions can be introduced making it possible amongst other things to use the results of a former calculation.

The loading is given in the form of a linear combination of generalized vectors and functions of time describing the temporal evolution of these vectors.

Six explicit methods of integration: 'EULER', 'DEVOGE', 'ADAPT\_ORDRE1' and 'ADAPT\_ORDRE2' (methods of integration with step of adaptive time of order 1 or ordre2), 'RUNGE\_KUTTA\_32' and 'RUNGE\_KUTTA\_54' (methods of integration to step of adaptive time of the family of Runge-Kutta with orders 54 and 32 respectively), an integral method 'ITMI' and a method of integration implicit: 'NEWMARK' are available. Explicit algorithms and 'ITMI' support calculation with taking into account of non-linearities located with the nodes of the shocks type and friction. Methods 'EULER', 'ADAPT\_ORDRE1' and 'ADAPT\_ORDRE2' support the taking into account of non-linearities of type antiseismic device. Methods 'RUNGE\_KUTTA\_32', and 'RUNGE\_KUTTA\_54' support the taking into account of non-linearities located with the nodes of the shocks type and friction as well as non-linearities of type antiseismic device.

To be able to calculate the answer of a revolving machine on non-linear stages, a coupler with code EDYOS was developed and requires the joint use of the keyword factors COUPLAGE\_EDYOS and PALIER\_EDYOS.

The structure of data `result` contains for various moments of calculation, the generalized results and the calculated forces of shock.

The conversion of the results generalized in physical space is possible by the operators `REST_GENE_PHYS` [U4.63.31] or for a component by `RECU_FONCTION` [U4.32.03].

Product a concept of the type `tran_gene`.

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## 2 Syntax

```

tranmo [tran_gene] = DYNA_TRAN_MODAL (
    ◊ reuse = tranmo,
    ◆ MATR_MASS = my, [matr_asse_gene_R]
    ◆ MATR_RIGI = laughed,
    [matr_asse_gene_R]
    ◊ MATR_AMOR = amndt,
    [matr_asse_gene_R]
    ◊ AMOR_MODAL = _F (
        / AMOR_REDUIT = , [l_R]
        / LIST_AMOR = l_amor, [listr8]
    ),
    ◊ SCHEMA_TEMPS = _F (
        ◆ DIAGRAM = (| 'NEWMARK', [DEFECT]
                    | 'EULER',
                    | 'DEVOGE',
                    | 'ADAPT_ORDRE1',
                    | 'ADAPT_ORDRE2',
                    | 'RUNGE_KUTTA_54',
                    | 'RUNGE_KUTTA_32',
                    | 'ITMI',
                    ),
        # Keywords only associated with the diagram 'NEWMARK' :
        ◊ BETA = /0.25, [DEFECT]
          /beta, [R]
        ◊ GAMMA = /0.5, [DEFECT]
          /gamma, [R]
        # Keywords only associated with the diagrams 'RUNGE_KUTTA_*':
        ◊ TOLERANCE = /1.E-3, [DEFECT]
          /tol, [R]
        ◊ ALPHA = /1.E-3, [DEFECT]
          /alpha, [R]
        # Keywords only associated with the diagram 'ITMI' :
        ◊ BASE_ELAS_FLUI= mix, [melasflu]
        ◊ NUME_VITE_FLUI= Nvitf, [I]
        ◊ ETAT_STAT = /'NOT', [DEFECT]
          /'YES',
        ◊ PREC_DUREE = /1.E-2, [DEFECT]
          /prec, [R]
        ◊ CHOC_FLUI = /'NOT', [DEFECT]
          /'YES',
        ◊ NB_MODE = Nmode, [I]
        ◊ NB_MODE_FLUI = Nmodef, [I]
        ◊ TS_REG_ETAB = tsimu, [R]
    ),
    ◆ INCREMENT = _F ( ◆ / LIST_INST = litps, [listr8]
                       / NOT = dt, [R]
        ◊ INST_INIT = Ti, [R]
        ◊ / INST_FIN= tf, [R]
          / NUME_FIN= nufin, [I]
        ◊ VERI_PAS = / 'YES', [DEFECT]
          / 'NOT',

```

## # Operands specific to an integration by step of adaptive times of order 1 and 2

```

◇ VITE_MIN = / 'NORM', [DEFECT]
/ 'MAXIMUM',
◇ COEF_MULT_PAS = / 1.1 , [DEFECT]
/ cmp , [R]
◇ COEF_DIVI_PAS = / 1.33333334, [DEFECT]
/ cdp , [R]
◇ PAS_LIMI_RELA = / 1.E-6, [DEFECT]
/ per , [R]
◇ NB_POIN_PERIODE = 50, [DEFECT]
/ NR, [I]
◇ NMAX_ITER_PAS = / 16, [DEFECT]
/ NR, [I]

```

## # Operands specific to an integration by step of adaptive times (order 1 and 2) like Runge-Kutta

```

◇ PAS_MAXI = dtmax, [R]
◇ PAS_MINI = dtmin, [R] ),
◇ ETAT_INIT = _F ( ◆ / =res RESULT, [tran_gene]
.. If RESULT
◇ /INST_INIT = to, [R]
/NUME_ORDR = No, [I]
◇ / CRITERION = 'RELATIVE', [DEFECT]
◇ PRECISION = / 1.E-06, [DEFECT]
/ prec, [R]
/ CRITERION = 'ABSOLUTE',
◆ PRECISION = prec, [R]
/ | DEPL = C, [vect_asse_gene]
| QUICKLY = vo,
[vect_asse_gene]
),
◇ EXCIT = _F ( ◇ VECT_ASSE_GENE = v, [vect_asse_gene]
◇ NUME_ORDRE = nmordr, [I]
◇ / FONC_MULT = F, [function]
/ COEF_MULT = has, [R]
/ ◇ ACCE = ac, [function]
◇ QUICKLY = VI, [function]
◇ DEPL = dp, [function]

```

## # Operands and keywords specific to the seismic analysis

```

◇ MULT_APPUI = / 'NOT', [ DEFECT]
/ 'YES',
◇ DIRECTION = (dx, Dy, dz, drx, dry Martini, drz),
[l_R]
◇ / NODE = lno, [l_noeud]
/ GROUP_NO = lgrno, [l_groupe_no]
◇ ◆ CORR_STAT = 'YES'
◆ D_FONC_DT = dfdt, [function]
◆ D_FONC_DT2 = dfdt2, [function]
),
◇ / MODE_STAT = psi, [mode_meca]
/ MODE_CORR = modcor, [mult_elas, mode_meca]
◇ EXCIT_RESU =
_F ( ◆ RESULT = resuforc, [tran_gene]
◇ /COEF_MULT = have, [R]
/COEF_MULT_C = aci, [C]
),

```

# End of the operands and keywords specific to the seismic analysis

```

◇ SHOCK = _F (
  ◇ ENTITLE = int, [l_Kn]
    / ◆ / NOEUD_1 = no1, [node]
      / / GROUP_NO_1 = grno1, [group_no]
    ◇ / NOEUD_2 = no2, [node]
      / / GROUP_NO_2 = grno2, [group_no]
    / ◆ / MESH = my, [mesh]
      / / GROUP_MA = grma, [group_ma]
    ◆ OBSTACLE = obs, [obstacle]
    ◆ NORM_OBST = NOR, [listr8]
    ◇ ORIG_OBST = ori, [listr8]
    ◇ GAME = / 1., [DEFECT]
      / game, [R]
    ◇ ANGL_VRIL = gamma, [R]
    ◇ DIST_1 = dist1, [R]
    ◇ DIST_2 = dist2, [R]
    ◇ SOUS_STRUC_1 = ss1, [K8]
    ◇ SOUS_STRUC_2 = ss2, [K8]
    ◇ REFERENCE MARK = / 'TOTAL',
[DEFECT]
      / nom_sst, [K8]
    ◇ RIGI_NOR = kN, [R]
    ◇ AMOR_NOR = / 0., [DEFECT]
      / Cn, [R]
    ◇ RIGI_TAN = / 0., [DEFECT]
      / kt, [R]
    ◇ AMOR_TAN = / ct, [R]
    ◇ FRICTION =
      / 'NOT' [DEFECT]
      / 'COULOMB'
        ◆ COULOMB = driven [R]
      / 'COULOMB_STAT_DYNA'
        ◆ COULOMB_STAT = driven [R]
        ◆ COULOMB_DYNA = mud [R]
# Operands specific to the taking into account of a transient speed
for the rotors (number of revolutions variable)
◇ VITESSE_VARIABLE = 'NOT', [DEFECT]
  / 'YES',
  # if VITESSE_VARIABLE=' OUI':
    ◆ VITE_ROTA = vrot, [function]
    ◆ MATR_GYRO = gyro, [matr_asse_gene_R]
    ◇ ACCE_ROTA = arot, [function]
    ◇ MATR_RIGY = gyro, [matr_asse_gene_R]
  # if VITESSE_VARIABLE=' NON':
    ◆ VITE_ROTA = / 0.0, [DEFECT]
      / vrot, [R]
# Keyword specific to the taking into account of a crack in a rotor
◇ ROTOR_FISS=_F (
  / ◆ / NOEUD_G = nog, [node]
    / / GROUP_NO_G = grnog, [group_no]
    ◆ / NOEUD_D = nod, [node]
      / / GROUP_NO_D = grnod, [group_no]
    ◆ ANGL_INIT = 0.0, [DEFECT]
    ◇ ANGL_ROTA = 0.0, [function]
    ◆ K_PHI = kphi [function]

```

```

        ◆ DK_DPHI = dkdphi [function]
    )

◇ VERI_CHOC = _F (
    ◇ STOP_CRITERE = / 'YES', [DEFECT]
                  / 'NOT',
    ◇ THRESHOLD = / 0.5, [DEFECT]
                  / S, [R]
    ),

◇ ANTI_SISM = _F (
    ◆ / NOEUD_1 = no1, [node]
      / GROUP_NO_1 = grno1, [group_no]
    ◆ / NOEUD_2 = no2, [node]
      / GROUP_NO_2 = grno2, [group_no]
    ◇ RIGI_K1 = / 0., [DEFECT]
              / kN, [R]
    ◇ RIGI_K2 = / 0., [DEFECT]
              / kN, [R]
    ◇ SEUIL_FX = / 0., [DEFECT]
                / Py, [R]
    ◇ C = / 0., [DEFECT]
          / C, [R]
    ◇ PUIS_ALPHA = / 0., [DEFECT]
                  / alpha, [R]
    ◇ DX_MAX = / 1., [DEFECT]
               / dx, [R]
    ),

◇ DIS_VISC = _F (
    ◆ / NOEUD_1 = no1, [node]
      / GROUP_NO_1 = grno1, [group_no]
    ◆ / NOEUD_2 = no2, [node]
      / GROUP_NO_2 = grno2, [group_no]

    ◆ / K1 = k1, [R]
      / UNSUR_K1 = usk1, [R]
    ◆ / K2 = k2, [R]
      / UNSUR_K2 = usk2, [R]
    ◆ / K3 = k3, [R]
      / UNSUR_K3 = usk3, [R]
    ◆ C = C, [R]
    ◆ PUIS_ALPHA = /=0.5 [defect]
                  /alpha, [R]

    ◇ ITER_INTE_MAXI =/=20 [defect]
                      /iter [I]
    ◇ RESI_INTE_RELA =/=1.0E-06 [defect]
                     /resi [R]
    ),

◇ BUCKLING = _F (
    ◆ / NOEUD_1 = no1, [node]
      / GROUP_NO_1 = grno1, [group_no]
    ◇ / NOEUD_2 = no2, [node]
      / GROUP_NO_2 = grno2, [group_no]
    ◆ OBSTACLE = obs, [obstacle]
    ◇ ORIG_OBST = ori, [listr8]
    ◆ NORM_OBST = NOR, [listr8]
    ◇ ANGL_VRIL = / 0, [DEFECT]
                 / gamma, [R]
    ◇ GAME = / 1., [DEFECT]
            / jeu, [R]
    ◇ DIST_1 = dist1, [R]
    ◇ DIST_2 = dist2, [R]

```

```

[DEFECT]          ◇ REFERENCE MARK = / 'TOTAL' ,
                  / nom_sst , [K8]
                  ◇ RIGI_NOR = kn, [R]
                  ◇ FNOR_CRIT = film, [R]
                  ◇ FNOR_POST_FL = fseuil, [R]
                  ◇ RIGI_NOR_POST_FL = k2, [R]
                  ),
◇ RELA_EFFO_DEPL = _F (
    ◆ _NODE = Noah, [node]
    ◇ SOUS_STRUC = ss, [K8]
    ◇ NOM_CMP = nomcmp, [K8]
    ◆ RELATION = F, [function]
    ),
◇ RELA_EFFO_VITE = _F (
    ◆ _NODE = Noah, [node]
    ◇ SOUS_STRUC = ss, [K8]
    ◇ NOM_CMP = nomcmp, [K8]
    ◆ RELATION = F, [function]
    ),

# Keywords factors only associated with the coupling with code EDYOS
◇ COUPLAGE_EDYOS = _F (
    ◆ VITE_ROTA = vrota, [R]
    ◆ PAS_TPS_EDYOS = dtedyos, [R]
    ),
◇ PALIER_EDYOS = _F (
    ◆ / UNIT = uled, [I]
    / GROUP_NO = grnoed, [group_no]
    / NODE = noed, [node]
    ◇ TYPE_EDYOS = / 'PAPANL',
                  / 'PAFINL',
                  / 'PACONL',
                  / 'PAHYNL',
    ),

# End of the keywords factors only associated with the coupling with code EDYOS
◇ FILING = _F ( ◇ / LIST_INST = list [listr8]
                / INST = in [R]
                / PAS_ARCH = ipa [I]
                ◇/ CRITERION = 'RELATIVE', [DEFECT]
                ◇ PRECISION = / 1.E-06, [ DEFECT]
                / prec, [R]
                / CRITERION = 'ABSOLUTE',
                ◆ PRECISION = prec, [R]
                ),
◇ SOLVEUR = _F (see [U4.50.01])
◇ INFORMATION = / 1,
[DEFECT]      / 2,
◇ IMPRESSION = _F (
    ◇ / ALL = 'YES', [DEFECT]
    / LEVEL = | 'DEPL_LOC',
              | 'VITE_LOC',
              | 'FORC_LOC',
              | 'TAUX_CHOC',
    ◇ INST_INIT = Ti, [R]
    ◇ INST_FIN = tf, [R]
    ◇ UNITE_DIS_VISC = [I]

```

# Code\_Aster

Version  
default

Titre : Opérateur DYNA\_TRAN\_MODAL  
Responsable : ALARCON Albert

Date : 10/07/2015 Page : 9/37  
Clé : U4.53.21 Révision :  
e156bdb12efd

```
),  
    ◇ TITLE = title, [1_Kn]  
)
```

## 3 Operands

### 3.1 Generalized matrices

In the case of a calculation by modal recombination, the generalized matrices must be established by the operator `PROJ_MATR_BASE` [U4.63.12] or by the macro-order `PROJ_BASE` [U4.63.11], starting from the same modal base.

In the case of a calculation by dynamic under-structuring, the generalized matrices must be established by the operator `ASSE_MATR_GENE` [U4.65.04], starting from same generalized classification.

- ◆ `MATR_MASS = my`  
Matrix of mass of the generalized system.  
Concept of the type `matr_asse_gene_R`.
- ◆ `MATR_RIGI = laughed`  
Matrix of rigidity of the generalized system.  
Concept of the type `matr_asse_gene_R`.
- ◇ `MATR_AMOR = amndt`  
Matrix of damping of the generalized system.  
Concept of the type `matr_asse_gene_R`.  
This option is not available with the method 'DEVOGE'.

### 3.2 Keyword `AMOR_MODAL`

This keyword makes it possible to take into account a damping equivalent to modal damping broken up on a basis of modes precalculated in the form of concept of the type `mode_meca`. This damping is taken overall into account in the dynamic equilibrium equation like a correct force with the second member  $-C\dot{X}$ .

#### 3.2.1 Operands `AMOR_REDUIT` / `LIST_AMOR`

◇ / `AMOR_REDUIT = L η`

List of reduced depreciation ( $\eta_1, \eta_2, \dots, \eta_n$  percentages of damping criticizes) corresponding to each mode of the system in the form of list of realities.

This option is not available in dynamic under-structuring because reduced depreciation must be defined for each substructure separately (operator `MACR_ELEM_DYNA` [U4.65.01]).

**Note:**

*If the number of reduced depreciation given is lower than the number of basic vectors used in the modal base, depreciation of the additional vectors is taken equal to the last damping of the list.*

/ `LIST_AMOR = c_formule η`

Name of the concept of the type `listr8` containing the list of reduced depreciation.

### 3.3 Diagrams of integration. Keyword `SCHEMA_TEMPS`

Under this keyword one can inform a diagram of integration with, possibly, his parameters. The diagrams available are to be declared under the operand `DIAGRAM`.

## 3.3.1 Operand DIAGRAM

◇ DIAGRAM =

Choice of the digital method of resolution.

In the case of a classical calculation by modal recombination, the user has six methods of the explicit type, an integral method and method of an implicit type.

In the case of a calculation by dynamic under-structuring [R4.06.04], the transitory method of calculating on modal basis calculated by under-structuring supports all the diagrams of integration evoked except the integral method. On the other hand, the transitory method of calculating on the "bases" of the substructures supports only the diagram of Euler and the diagrams with step of adaptive time.

### 3.3.1.1 DIAGRAM = 'NEWMARK' : implicit scheme

This diagram allows only the integration of linear problems. It is the diagram by default for the resolution. One can specify the parameters of integration  $\beta$  and  $\gamma$  :

◇ BETA = beta

Value of the parameter  $\beta$  for the method of NEWMARK. By default  $\beta=0.25$  .

◇ GAMMA = gamm

Value of the parameter  $\gamma$  for the method of NEWMARK. By default  $\gamma=0.5$  .

### 3.3.1.2 DIAGRAM = 'EULER' : diagram clarifies order 1

This diagram supports calculation with taking into account of the whole of localised non-linearities available.

### 3.3.1.3 DIAGRAM = 'DEVOGE' : diagram clarifies order 4

The diagram of DEVOGELAERE supports calculation with taking into account of the whole of localised non-linearities available.

### 3.3.1.4 DIAGRAM = 'ADAPT\_ORDRE2' : diagram clarifies order 2

This diagram (called 'ADAPT' in the previous versions of the code) calculation with taking into account of the whole of localised non-linearities available supports. This method uses the diagram of the centered differences, the algorithm of adaptation of the step of time is based on the calculation of a "apparent frequency":

$$f_{APt} = \frac{1}{2\pi} \sqrt{\left| \frac{\ddot{x}_t - \ddot{x}_{t-1}}{x_t - x_{t-1}} \right|}$$

One specifies Ci after the operands specific to the method of integration per step of adaptive times. They are the operands following of the keyword factor INCREMENT :

◇ NB\_POIN\_PERIODE = NR

Many points per apparent period. It is this parameter which fixes the precision of calculation. It must be at least equal to 20; its value by default (50) guarantees a satisfactory precision (about 1%) in most case.

◇ VITE\_MIN =

Method of calculating the speed of reference used to evaluate the apparent frequency.

When the denominator of the frequency connects ( $x_n - x_{n-1}$ ) becomes weak, this one can become very high, which leads to an unjustified refinement of the step of time. To cure it, the algorithm uses the following criterion:

$$\frac{|x_n - x_{n-1}|}{\Delta t} \leq V_{min} \Rightarrow f_{APn} = \frac{1}{2\pi} \sqrt{\frac{\ddot{x}_n - \ddot{x}_{n-1}}{V_{min} \Delta t}}$$

$V_{min}$  can be calculated in two ways different according to the value from VITE\_MIN :

$$\text{'NORM'} = V_{min}(t_n) = \frac{\|V(t_n)\|}{100} \text{ for all the degrees of freedom.}$$

Can be used:

- if the system has several degrees of freedom,
- if the order of magnitude of displacement is not too different according to the degrees of freedom.

$$\text{'MAXIMUM'} = V_{min}^i(t_n) = \frac{\text{Max}(|V^i(t_p)|)}{100} \text{ for the degree of freedom } i.$$

Can be used:

- if the system has a small number of degrees of freedom (from 1 to 3),
- for a system with several degrees of freedom, if the order of magnitude of displacement is very different according to the degrees of freedom (for example in the presence of degrees of freedom of Lagrange under - structuring),
- if the order of magnitude speed does not vary too much in the course of time.

◇ NMAX\_ITER\_PAS = NR

Maximum number of reductions of the step of time per step of calculation. It is by default equal to 16, which limits the coefficient of reduction of the step to  $0,75^{16} = 10^{-2}$  by iteration (when the step of time is too high, one takes again calculation with a weaker step:  $\Delta t_n' = 0,75 \Delta t_n$ ).

NMAX\_ITER\_PAS can be:

- increased to allow the step time to fall in a more brutal way,
- decreased if the step of time seems excessively refined, for example in the presence of discontinuities (solid friction, discontinuous excitation,...).

If, at a given moment, one reaches this maximum number of successive reductions of the step of time, then the code nevertheless will consider that the final step is correct and will pass to the following step. A message of alarm is then transmitted, which announces a possible risk of loss of precision and which advises with the user to start again calculation with parameters modified (while playing on NOT, NMAX\_ITER\_PAS and/or COEF\_DIVI\_PAS) to allow to cross the difficulty with a step of smaller time.

◇ COEF\_MULT\_PAS = cmp

Coefficient of increase in the step when the error is sufficiently weak:

$$\Delta t_n < \frac{0,75}{Nf_{APn}} \Rightarrow \Delta t_{n+1} = \text{cmp} \Delta t_n.$$

Its value by default (cmp=1.1) guarantees stability and precision, but it can in general be increased (with more until 1.3) to accelerate integration.

◇ COEF\_DIVI\_PAS = cdp

Coefficient of refinement of the step of time (>1) when the error is higher than 1, that the iteration count maximum (N\_MAX\_ITER\_PAS) is not reached and that the step of minimal time is

not reached:

$$\Delta t_n < \frac{1}{Nf_{APn}}, N_{iter} < N_{iter\_max} \text{ and } \Delta t_n > \text{plr} \Delta t_{initial}$$
$$\Rightarrow \Delta t_n = \frac{\Delta t_n}{\text{cdp}}$$

The value by default is of 1.33333334 , that is to say a reduction of a factor 0.75 .

◇ PAS\_LIMI\_RELA = plr

Coefficient applied to the step of initial time to define the limit of refinement and thus the step of minimal time:

The value by default is of 1.33333334 , that is to say a reduction of a factor 0.75 .

$$\Delta T_{min} = \text{plr} \Delta t_{initial}$$

### 3.3.1.5 DIAGRAM = 'RUNGE\_KUTTA\_54' : explicit diagram with adaptive step.

This diagram is part of the family of the diagrams of integration of the Runge-Kutta type. In particular, it is the explicit diagram of integration of Dormand-Prince (54) [R5.06.04] with step of adaptive time. The diagram 'RUNGE\_KUTTA\_54' support the taking into account of all nonthe - linearities available in the operator.

The calculation of the step of optimal time is done by control of the error between the approximations of order 5 and 4 of the prediction of the vector of state (concatenation of the vectors of displacement and speed).

This diagram is based on the condition of control of the following relative error:

$$err \leq tol$$

with

$$err = \frac{1}{n} \sum_i \sqrt{\left(\frac{y_{i5} - \hat{y}_{i4}}{sc_i}\right)^2} \text{ and } sc_i = MAX(|y_{i0}|, |y_{i1}|) + \alpha$$

where

- $y_{i5}$  is the value of the prediction of order 5 of the component  $i$  vector of state  $y$
- $\hat{y}_{i4}$  is the value of the prediction of order 4 of the component  $i$  vector of state  $y$
- $n$  is the size of the vector of state  $y$
- $y_{0i}$  is the value of the component  $i$  vector of state  $y$  with the actual position

◇ TOLERANCE = tol

Value of control of relative error given by the user. By default it is worth 1.E-3.

◇ ALPHA = alpha

Value of regularization given by the user intervening in the expression of  $sc_i$  . By default it is worth 1.E-3.

### 3.3.1.6 DIAGRAM = 'RUNGE\_KUTTA\_32' : explicit diagram with adaptive step.

Like the diagram 'RUNGE\_KUTTA\_54', the diagram 'RUNGE\_KUTTA\_32' fact part of the family of the diagrams of integration of the Runge-Kutta type. In this case, it is the explicit diagram of integration of Bogacki-Shampine (32) [R5.06.04] with step of adaptive time.

Like the preceding diagram, it supports the taking into account of the whole of non-linearities available in the operator.

For this diagram, the calculation of the step of optimal time is done by control of the error between the approximations of order 3 and 2 of the prediction of the vector of state. The calculation of the step of optimal time, as for him, is done in a way similar to the preceding diagram.

### 3.3.1.7 DIAGRAM = 'ADAPT\_ORDRE1' : diagram clarifies order 1

This diagram is an alternative of the preceding diagram 'ADAPT\_ORDRE2'. It is in fact a version of the diagram of Euler with step of adaptive time. Apart from this difference, this diagram is used same manner as the adaptive diagram of order 2: the syntax of the keyword is the same one and the methods of piloting of the step of time too.

### 3.3.1.8 DIAGRAM = 'ITMI' : diagram integral for the calculation of the answer of mechanical systems very slightly deadened with couplings fluidelastic

This diagram of integration by integral method allows, for the slightly deadened systems, to obtain an exact answer by taking account of the variations of fluidelastic forces obtained in the presence of shocks.

One describes Ci below the keywords specific to the calculation of the answer of linear mechanical systems very slightly deadened with couplings fluidelastic possibly associated with non-linearities located with the nodes of the shocks type and frictions.

◇ BASE\_ELAS\_FLUI = mix

Base modal used for calculation.

Concept of the type melasflu product by the operator CALC\_FLUI\_STRU [U4.66.02] which contains the whole of the modal bases calculated for different the rate of flow definite. This keyword is obligatory for the method 'ITMI'.

Transitory calculation on modal basis modified by the coupling fluidelastic is carried out by taking of account the values of added depreciation, which had with the flow of the fluid, which is present in the concept melasflu of entry. **Modal depreciation, recovered base fluidelastic, those well informed under the keyword replace total AMOR\_REDUIT of the operator DYNA\_TRAN\_MODAL.**

◇ NUME\_VITE\_FLUI = Nvitf

Rate of flow retained for calculation (sequence number).

Allows to extract in the concept melasflu the modal base corresponding to the rate of flow retained (cf [U4.66.02]). This keyword is obligatory for the method 'ITMI'.

◇ ETAT\_STAT =

For the systems very slightly deadened, this option makes it possible to avoid an expensive calculation of the linear phase preceding the first shock. This phase, called thereafter "transitional stage" precedes the establishment by a mode made up of a succession of nonlinear phases of shocks and/or linear phases called of "flight" according to the functions of excitation of the mechanical system applied. The time of transient corresponds to a displacement equal to the game of a thrust. It can be relatively important (50 to 100 seconds).

ETAT\_STAT = 'YES' : the passage in only one step of computing time of the transitional stage allows.

The passage of the transitional stage is carried out by supposing the mechanical system in "flight". The time necessary on the way of the transient is estimated by the algorithm according to the mechanical characteristics of the system in "vol". This estimate is based on a criterion where intervene the parameter `PREC_DUREE` and durations of excitations due to the turbulent efforts.

## Note:

*If one asks for a simulation with calculation in a step of time of the transitional stage, it will be necessary to take care to introduce one duration of sufficiently long excitation. This duration must correspond to the duration necessary on the way of the transient increased by the duration of simulation in established mode wished. This total duration of simulation will be indicated via the two operands `INST_INIT` and `INST_FIN` under the keyword factor `INCREMENT`.*

`ETAT_STAT = 'NOT'` : Simulation does not distinguish the transitory state from the established mode.

◇ `PREC_DUREE = prec`

Allows to define the precision chosen to determine the duration of the transitional stage according to the formula:

$$T_{tr} = \frac{-\ln(\text{prec})}{2\xi_0\omega_0} \text{ where } \xi_0 \text{ and } \omega_0 \text{ reduced damping and the pulsation of each mode}$$

considered indicate respectively. The value by default of this parameter is 1%.

◇ `CHOC_FLUI =`

Determine the treatment carried out by the algorithm during the phases of shock with respect to the fluidelastic forces.

By default, the variation of the fluidelastic forces in phase of shock related to the modification of the rigidity and the damping of the mechanical system (impact on the thrust) is not taken into account.

◇ `NB_MODE = Nmode`

Many modes of the modal base retained for dynamic calculation.

The preserved modes correspond to increasing frequencies (first modes). If `NB_MODE` is not specified, one takes all the modes of the modal base of the concept of the type `melasflu`.

◇ `NB_MODE_FLUI = Nmodef`

Many modes of the modal base disturbed by the fluidelastic phenomena of coupling in phase of shock (lower than the number of modes retained for dynamic calculation).

The preserved modes correspond to `Nmodef` first increasing frequencies (first modes). If `NB_MODE_FLUI` is not specified, one takes the number of modes retained for dynamic calculation.

◇ `TS_REG_ETAB = tsimu`

Duration of desired simulation.

In the case of a simulation without preliminary calculation and in a step of time of the transitional stage (`ETAT_STAT = 'NOT'`), this duration corresponds to the duration of simulation whatever the state of the system between the moments of beginning and end of simulation. Consequently one will have to make sure that:

$$TS\_REG\_ETAB \leq INST\_FIN - INST\_INIT$$

By default, one will have `TS_REG_ETAB = INST_FIN - INST_INIT`

In the case of a simulation with calculation of the transitional stage ( `ETAT_STAT = 'YES'` ), this duration corresponds to the duration of really desired simulation when the phase of shocks is established from the digital point of view. Consequently one will have to make sure that:

$$TS\_REG\_ETAB \leq INST\_FIN - INST\_INIT - \text{"time considered transitory"}$$

If this last condition is not observed, the user is informed with precision of the minimum time of excitation necessary for his calculation `INST_FIN - INST_INIT`.

By default, one has : `TS_REG_ETAB = INST_FIN - INST_INIT - "time considered transitory"`

**Note:**

*This diagram of integration is not usable in continuation and does not allow calculation by under - dynamic structuring.  
The presence of the keyword `SHOCK` is imperative even for simulations of phases without shocks known as 'phases of flight'.*

## 3.4 Keyword INCREMENT

### 3.4.1 Operands `LIST_INST` / `NOT/VERI_PAS/PAS_MINI/PAS_MAXI`

- ◆ / `LIST_INST = l_temp`  
Concept lists realities of the type `listr8`.  
List of realities defining the moments  $t_i$  of calculation of the solution

- Diagrams `'RUNGE_KUTTA_54'` and `'RUNGE_KUTTA32'` :  
For the diagrams of the Runge-Kutta type, the keyword `LIST_INST` is not taken into

account.

$$/ \quad NOT = dt$$

- Diagrams `'EULER'`, `'DEVOGE'`, `'NEWMARK'` :  
Pas de time of transitory calculation.

- Diagrams `'ADAPT_ORDRE1'` and `'ADAPT_ORDRE2'` :  
Indicate the step of initial time used by the algorithm.  
This parameter must be sufficiently weak:

- to allow the calculation of the static phases (which always uses the step of maximum time),
- to start the algorithm correctly.

It must however be sufficiently high not to penalize the whole of calculation.

- Diagram `'ITMI'` :

Indicate the step of time appointed for the first step of calculation (after possible passage of the transient). Thereafter, the algorithm automatically manages the step of calculation according to the rigidity of the structure and the zones of transition flight/shock.

- Diagrams `'RUNGE_KUTTA_54'` and `'RUNGE_KUTTA32'` :

Indicate the step of initial time suggested by the user. If the error of prediction between the control statements checks  $err \leq 1$ , then it is the first step of calculation. If not, the algorithm automatically chooses the step of time necessities in order to check this condition. Thereafter, the choice of the step of time in the algorithms of Runge-Kutta is managed automatically.

- ◆ `VERI_PAS = reference mark`

Checking of the step of computing time compared to step of given time limits according to the highest frequency of the modes of the modal base considered or the bases of under - structures.

# Operands specific to an integration by step of adaptive times with the diagrams 'ADAPT\_ORDRE1', 'ADAPT\_ORDRE2' like 'RUNGE\_KUTTA\_54' and 'RUNGE\_KUTTA\_32'.

◇ PAS\_MAXI = dtmax

Maximum value of the step of time. If the conditions of increase in the step of time are met, the step of current time will be able to then increase up to this limiting value.

If the user does not give a value to this optional parameter, diagrams 'ADAPT\_ORDRE1', 'ADAPT\_ORDRE2' will consider a value noted *dt<sub>s</sub>* starting from the cut-off frequency of the base (possibly corrected by the stiffnesses of shocks). On the other hand, the diagrams of Runge-Kutta will not have any limitation superior in terms of step of time.

To find the operation of the previous versions of the code, it is enough to force:  
*dtmax = dt*, therefore the same value with the parameter NOT that with PAS\_MAXI.

If the user gives a value higher than *dt<sub>s</sub>*, an alarm will be emitted attentive of a risk of loss of precision.

◇ PAS\_MINI = dtmin

Minimal value of the step of time. If the conditions of reduction in the step of time are met, the step of current time will be able to then decrease up to this limiting value.

If the user does not give a value to this optional parameter, then the code will calculate the step of minimal time from PAS\_LIMI\_RELA.

To find the operation of the previous versions of the code, it is thus enough not to define PAS\_MINI.

## 3.4.2 Operands INST\_INIT/INST\_FIN/NUME\_FIN

◇ INST\_INIT = t<sub>o</sub>

- Methods 'EULER', 'DEVOGE', 'NEWMARK', 'ADAPT\_ORDRE1' and 'ADAPT\_ORDRE2' :

Moment of beginning of transitory calculation. In the event of recovery, the keyword is used ETAT\_INIT : under this keyword, the initial moment is recovered with the operand INST\_INIT or taken equal to the last moment of filed preceding calculation. The operand INST\_INIT must thus be only used if there is no resumption of a preceding calculation.

- Diagram 'ITMI' :

Indicate the moment of beginning of simulation. When calculation in a step of time of the transitional stage is required, simulation begins with INST\_INIT + "computing time of the transient"

◇ / INST\_FIN = t<sub>f</sub>

Moment of end of simulation.

/ NUME\_FIN = t<sub>f</sub>

Number of the moment of end of calculation in LIST\_INST

## 3.5 Keyword ETAT\_INIT

Keyword factor which allows a continuation of a transitory calculation, while taking as initial state:

- that is to say a result resulting from a calculation by modal synthesis preceding EXCIT (RESULT);
- maybe displacements and speeds expressed in the form of generalized assembled vectors EXCIT (DEPL and QUICKLY)

**Note:**

- *This functionality is not available for a calculation by transitory under-structuring without double projection nor for method ITMI.*
- *At the time of a continuation, the state of adherence or shock is not saved.*
- *Displacements and speeds generalized must be established by the operator PROJ\_VECT\_BASE [U4.63.13] starting from the modal base used for the matrices of rigidity generalized or by the operator RECU\_GENE [U4.71.03] applied to a preceding calculation.*

### 3.5.1 Operands RESU/DEPL/QUICKLY

◆/ RESULT = tran

Concept of the type tran\_gene resulting from a preceding calculation with DYNA\_TRAN\_MODAL.

/ | DEPL = C

Concept of the type vect\_asse\_gene, initial generalized displacements.

| QUICKLY = vo

Concept of the type vect\_asse\_gene, initial generalized speeds.

### 3.5.2 Operands INST\_INIT/NUME\_ORDR

◇ / INST\_INIT = to

Moment of preceding calculation to in the case of extract and take as initial state a recovery. In the absence of this operand, the moment of recovery is taken equal to the last moment of filed preceding calculation.

/ NUME\_ORDRE = nuord

Désigne the number of filing of preceding calculation to in the case of extract and take as initial state a recovery.

### 3.5.3 Operand CRITERION

◇ CRITERION

Indicate with which precision the research of the moment must be done:

'RELATIVE' : interval of research [(1-prec) .instant, (1+prec) .instant]

'ABSOLUTE' : interval of research [moment-prec, instant+prec]

The criterion is 'RELATIVE' by default.

### 3.5.4 Operand PRECISION

◇ PRECISION = / 1.E-06 [DEFECT]  
/ prec [R8]

Indicate with which precision the research of the moment must be done.

## 3.6 Description of the loading under separate variables: keyword EXCIT

◇ EXCIT

Keyword defining the loading. This keyword must be repeated as many times as there are vectors generalized loading  $f_i$ . The total loading is the sum of these vectors loading. This keyword makes it possible to define the loading under has the shape of generalized vectors multiplied by multiplying functions.

### 3.6.1 Operands VECT\_ASSE\_GENE/NUME\_ORDRE

The loading is taken into account in the form of vector project on the modal basis `EXCIT=_F` (`VECT_ASSE_GENE`) or in the form of modal component `EXCIT =_F` (`NUME_MODE`) or both at the same time.

~ VECT\_ASSE\_GENE = v

Generalized vector allowing to describe the space distribution of the loading.  
Concept of the type `vect_asse_gene`.

The generalized vectors must be establish by the operator `PROJ_VECT_BASE` [U4.63.13] starting from the modal base used for the generalized matrices. In the case of a calculation by dynamic under-structuring, the generalized vectors must be establish by the operator `ASSE_VECT_GENE` [U4.65.05] starting from the generalized classification used for the generalized matrices.

/ NUME\_ORDRE = nmordr

Sequence number of the mode of excitation of the structure (Attention! One should not confuse the sequence number of the mode – given by modal calculation in the order where they have calculated – and the number of the mode, entitled in *Code\_Aster* `NUME_MODE`).

### 3.6.2 Operand FONC\_MULT/COEF\_MULT

♦ / FONC\_MULT = F

Function of time (function) allowing to describe the temporal evolution of the vector loading.

/ COEF\_MULT = has

Multiplying coefficient of the generalized vector (constant actual value compared to time).

## 3.7 Keyword EXCIT\_RESU

Keyword allowing to define a loading in the form of a generalized temporal evolution, without separation of variables (case more the general). This temporal evolution can be calculated starting from the operator `PROJ_BASE`, option `RESU_GENE`, which carries out the projection of a transitory dynamic result (`dyna_trans`).

### 3.7.1 Keyword RESULT

♦ / RESULT = resu\_gene

Structure of data `resu_gene` defining the generalized loading.

### 3.7.2 Operand COEF\_MULT

◇ / COEF\_MULT = F

Multiplying coefficient, is worth 1.0 by default.

## 3.8 Typical case of the seismic analysis

### 3.8.1 Taking into account of the modes neglected by static correction: keywords `CORR_STAT`, `MODE_CORR` and `D_FONC_*`

During the seismic analysis of an excited mono structure, it is possible to take into account, a posteriori, the static effect of the neglected modes. In this case, at the time of the return on the physical basis, calculated relative displacements (respectively relative speeds and accelerations) are corrected by a pseudo-mode.

One will find the details of this kind of correction in [R4.05.01].

Inside the keyword factor `EXCIT`, `CORR_STAT=' OUI'` the taking into account of the modes neglected by static correction allows, it is then obligatory to inform the keywords `MODE_CORR`, `D_FONC_DT` and `D_FONC_DT2`.

◇ `MODE_CORR = modcor`

Concept of the `mult_elas` type produces by the macro-order `MACRO_ELAS_MULT` [U4.51.02] or `mode_meca` which corresponds to the linear static response of the structure to a unit loading of type forces imposed (constant acceleration) in the direction of the earthquake considered.

It is noted that there is as much loading case than of direction of earthquake.

◇ `EXCIT = _F (CORR_STAT)`

If `MODE_CORR` is present, `CORR_STAT=' OUI'` allows to take into account the contribution of the modal correction a posteriori for each occurrence of the keyword `EXCIT`.

◇ `EXCIT = _ F ( D_FONC_DT and D_FONC_DT2 )`

`D_FONC_DT` and `D_FONC_DT2` are respectively the derivative first and derived seconds of the time of the definite accélérogramme, in each seismic direction considered, by the operand `FONC_MULT`. They balance the contribution of the modal correction a posteriori for each occurrence of the keyword `EXCIT` in order to respectively obtain the corrections speed and acceleration on the physical basis.

#### Note:

- *The taking into account of the static correction excludes that from the multi-supports.*
- *The concept `mult_elas` must be based on a coherent classification of the equations (even profile and even option of renumeration) with that of the system solved in the operator `DYNA_TRAN_MODAL`.*
- *With  $i$  ème occurrence of the keyword `EXCIT` corresponds  $i$  ème elastic solution of `MODCOR`.*
- *So that the static correction is actually taken into account at the time of the return towards the physical coordinates in the operator `REST_GENE_PHYS` or `RECU_FONCTION` it is necessary to specify `CORR_STAT=' OUI'`.*

### 3.8.2 Taking into account of the multi-supports: keywords `MODE_STAT`, `MULTI_APPUI` and `ACCE`, `QUICKLY`, `DEPL`

In the case of a multimedia structure, in order to restore the sizes calculated in the absolute reference mark or to take into account nonlocated linearities, it is necessary to calculate the answer generalized by taking of account the component of training.

For more details, one will refer to the reference [R4.05.01].

Keywords `MODE_STAT`, `MULT_APPUI`, `ACCE`, `QUICKLY`, `DEPL`, `DIRECTION` and `NODE` or `GROUP_NO`) specific to the taking into account of the multimedia character must be simultaneously present.

One `cham_no` resulting from the projection of one `CALC_CHAR_SEISME` represent the vector of excitation on the support. It should not be forgotten, even if information can appear redundant with the data of the support and the direction of earthquake.

◇ `MODE_STAT = psi`

Concept of the type `mode_meca` product by the order `MODE_STATIQUE` [U4.52.14] which corresponds to (3 or 6) `nb_supports` static modes (where `nb_supports` is the number of supports which undergo a different acceleration).

◇ `EXCIT = _F (MULT_APPUI)`

If one calculates the seismic answer of a multimedia structure, `MULT_APPUI = 'YES'`, one compared to each moment, the vector of absolute displacements of each point of shock considered, in order to determine if there is shock and to calculate the corresponding forces of shock. If not, `MULT_APPUI = 'NOT'`, one compared to each moment, the vector of relative displacements of each node likely to shock.

◇ `EXCIT = _F ( / ◇ ACCE = ac,`  
◇ `QUICKLY = VI,`  
◇ `DEPL = dp)`

Names of the functions acceleration (`ACCE`), speed (`QUICKLY`) and displacement (`DEPL`) imposed during the calculation of the seismic answer of multimedia structures.

**Note:**

| *If the structure is mono-excited, the accélérogramme is defined by the keyword `FONC_MULT`.*

◇ `EXCIT = _F (DIRECTION = (dx, Dy, dz, drx, dry Martini, drz))`

Components of the vector giving the direction of the earthquake in the total reference mark.

◇ `EXCIT = _F ( / NODE = lno`  
/ `GROUP_NO = lgrno)`

List of the names of nodes (or group of nodes) corresponding to the supports concerned where the earthquake is imposed.

◇ `EXCIT = _F (VECT_ASSE_GENE = v)`

Vector project of the seismic excitation (resulting from `CALC_CHAR_SEISME` [U4.63.01])

## 3.9 Taking into account of a transient number of revolutions

### 3.9.1 Operand `VITESSE_VARIABLE`

Specify if the number of revolutions of the rotor is variable according to time (`VITESSE_VARIABLE = 'YES'` for the transients of speed) or constant (`VITESSE_VARIABLE = 'NOT'`).

### 3.9.2 Operands `VITE_ROTA`, `MATR_GYRO`, `ACCE_ROTA` and `MATR_RIGY`

These operands are the parameters defining the transient number of revolutions.

If `VITESSE_VARIABLE = 'YES'`, then should be informed the following parameters:

- ◇ `QUICKLY_ROTA` = function giving the angular law velocity imposed on the rotor
- ◇ `MATR_GYRO` = gyroscopic matrix of damping
- ◇ `ACCE_ROTA` = function giving the law of angular acceleration imposed on the rotor
- ◇ `MATR_RIGY` = gyroscopic matrix of stiffness

**Note:**

| If ACCE\_ROTA is not provided, it is neglected (IE. no digital derivation from QUICKLY\_ROTA ).

If VITESSE\_VARIABLE = 'NOT', it is necessary to inform the value number of constant revolutions.  
◆ VITE\_ROTA = lives ess of rotation of the tree [by default 0.0]

## 3.10 Taking into account of nonlocalised linearities of standard shock, friction, and fissured rotor

### 3.10.1 Not localised linearities of standard shock and friction: keyword SHOCK

◆ SHOCK

This keyword factor is used for the study of the answer of structures (generally slim) whose displacements are limited in one (or several) (S) - not specified a priori by the user by the presence of an obstacle (the various types of obstacles available are described in the documentation [U4.44.21] of the operator DEFI\_OBSTACLE), of another antagonistic structure.

#### 3.10.1.1 Operand ENTITLE

◆ ENTITLE = int

Heading (eight characters to the maximum) allowing to name non-linearity. If nothing is specified by the user, the heading is the name of NOEUD\_1.

#### 3.10.1.2 Operands NOEUD\_1/NOEUD\_2/GROUP\_NO\_1/GROUP\_NO\_2. /GROUP\_MA

◆ NOEUD\_1 or GROUP\_NO\_1

Node or name of the group of node of the structure to which the condition of non-linearity relates. In the case of a non-linear calculation by dynamic under-structuring, one indicates under this keyword the node of shock pertaining to the first substructure (the different ones under - structures do not belong to the same grid).

◆ NOEUD\_2 or GROUP\_NO\_2

Node or name of the group of node of the second structure to which the condition of non-linearity relates. This operand is specific to the definition of a contact between two mobile structures. In the case of a non-linear calculation by dynamic under-structuring, one specifies the node of shock coinciding with the node indicated in NOEUD\_1 (or GROUP\_NO\_1), but pertaining to the second substructure.

#### Note:

| It is checked that the groups of nodes contain well one and only one node.

◆ GROUP\_MA or MESH

One can also enter the nodes of shocks in opposite in the shape of meshes SEG2 drawn the grid. Thus one preserves the same way of describing the shocks as for DYNA\_NON\_LINE with the discrete elements of shock (DIS\_CHOC). One can enter a list of MESH or of GROUP\_MA.

#### 3.10.1.3 Operand OBSTACLE

◆ OBSTACLE = obs

Name of concept of the type obstacle defining the geometry of an indeformable obstacle or the form game between two antagonistic structures wraps. It is produced by the operator DEFI\_OBSTACLE [U4.44.21].

#### 3.10.1.4 Operand NORM\_OBST

◆ NORM\_OBST = NOR

List of 3 realities defining the normal in the plan of cut of the obstacle, i.e. the vector  $X_{loc}$ . One advises that  $X_{loc}$  that is to say direction of neutral fibre or a generator of the studied structure.

### 3.10.1.5 Operand ORIG\_OBST

◇ ORIG\_OBST = ori

List of 3 realities defining the position of the origin of the obstacle in the total reference mark (obligatory keyword in the case of shocks between a mobile structure and a fixed wall). In the case of shocks between two mobile structures, the code considers by default that the origin is located in the middle of the two nodes of shock NOEUD\_1 (or node of GROUP\_NO\_1) and NOEUD\_2 (or node of GROUP\_NO\_2).

### 3.10.1.6 Operand GAME

◇ GAME = game

In the case of a shock enters a mobile structure and an indeformable obstacle, the operand GAME represent:

- the half-distance inter-plans for obstacles of the type PLAN\_Y and PLAN\_Z
- the ray of the circular obstacle for an obstacle of the type CIRCLE

This keyword is unutilised in the case of obstacles discretized by segments of the type DISCRETE.

#### Note:

*The obstacle of the type PLAN\_Y or PLAN\_Z comprise in fact two obstacles plans. Thus if the user wishes to model the shock on a single level, not to be constrained by the rebound of structure studied on the symmetrical level, one advises with the user to very push back it far (cf [3.6.1.6 Figure - has]), J represents the real game between the studied structure and the obstacle .*

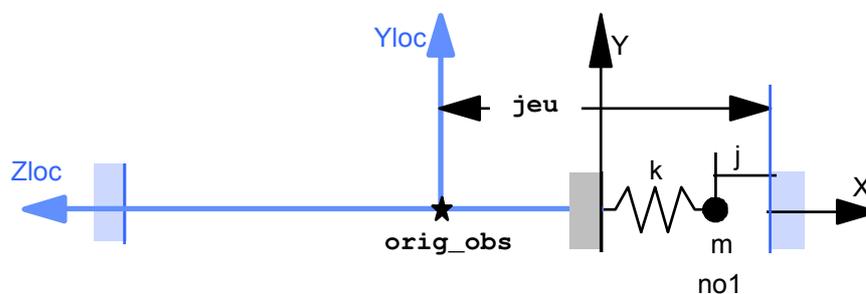


Figure 3.6.1.6 - has: System mass-arises impacting a fixed wall

#### Notice :

*The keyword GAME in the case of shock between mobile structures is not used.*

The various cases of games are represented in the documentation of DEFI\_OBSTACLE [U4.44.21].

### 3.10.1.7 Operand ANGL\_VRIL

◇ ANGL\_VRIL = gamma

$\gamma$ , angle in degrees defining the angular position of the local reference mark of the obstacle in its plan.

By convention, the normal  $n$  with the plan of cut of the obstacle, NORM\_OBST the axis defines  $X_{loc}$  local reference mark. One passes from the total reference mark  $X, Y, Z$  with the

reference mark of the plan of the obstacle  $n, y_2, z_2$  by a product of two rotations of angles  $\alpha$  around  $Z$  then  $\beta$  around transformed  $y_1$  of  $Y$ .

The position of the obstacle in this plan is obtained by a rotation of angle  $\beta$  around the normal direction  $X_{loc}$  (cf [3.6.1.7 Figure - has]).

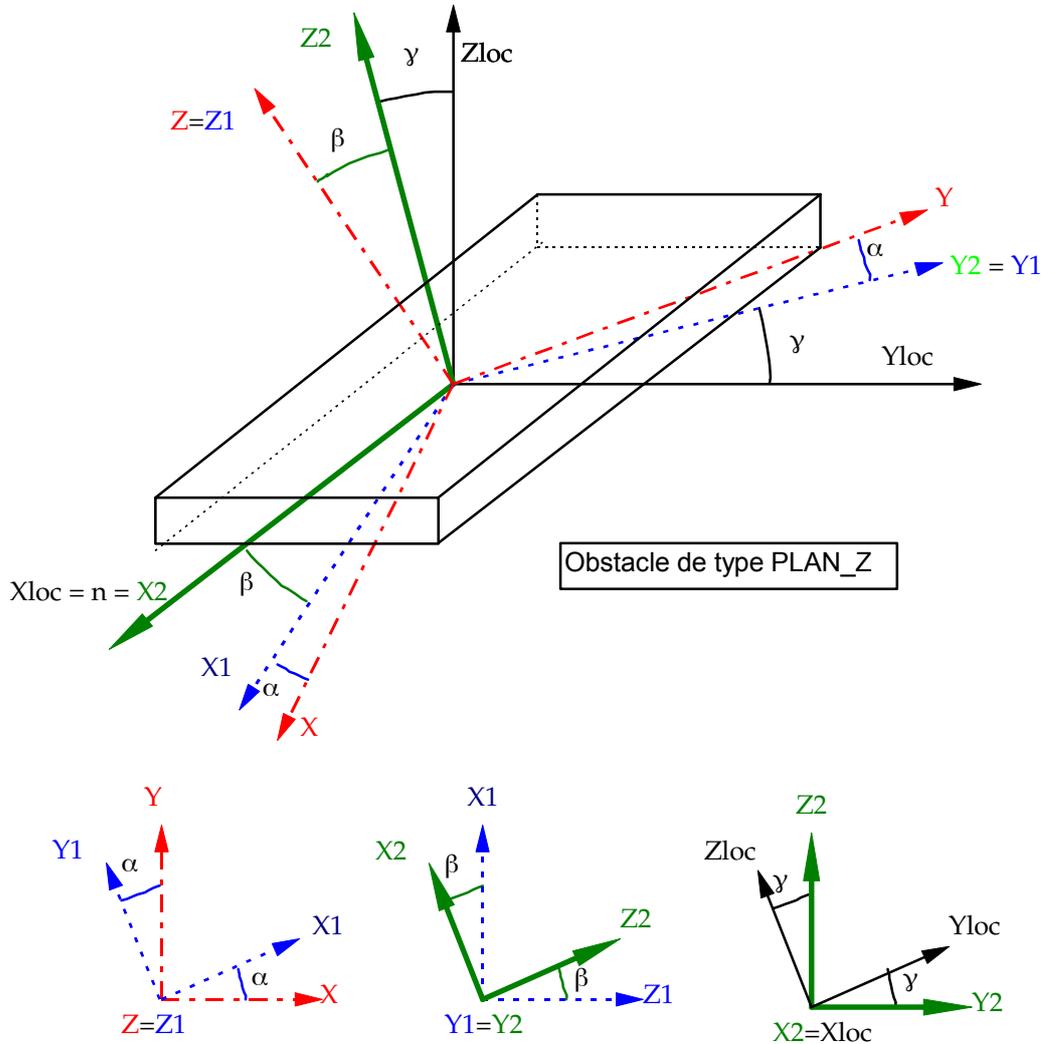


Figure 3.6.1.7 - has: Rotations allowing to pass from the total reference mark to the local reference mark of the obstacle.

Angles  $\alpha$  and  $\beta$  are automatically given starting from the normal with the obstacle  $n$ . The local reference mark  $X_{loc}, Y_{loc}, Z_{lo}$  results then from the reference mark  $n, y_2, z_2$  by rotation of an angle of gimlet ANGL\_VRIL around  $n$ .

**Note:**

- If the user does not specify anything, the angle of gimlet is calculated by the code in the case of shocks between mobile structures with obstacles of the type BI\_PLAN.
- With regard to the other types of obstacles, the value by default of gamma is zero.

### 3.10.1.8 Operands DIST\_1/DIST\_2

◇ DIST\_1 = dist1

Distance characteristic of matter surrounding NOEUD\_1: no1 (or GROUP\_NO\_1).

Operand specific to the contact between two mobile structures.

◇ `DIST_2 = dist2`

Distance characteristic of matter surrounding `NOEUD_2`: `no2` (or `GROUP_NO_2`).  
Operand specific to the contact between two mobile structures.

**Note:**

- *`DIST_1` and `DIST_2` are defined within the meaning of the outgoing normals of the two solids out of screw - with-screw ( `DIST_1` and `DIST_2` are positive because they represent the thickness of the studied structures).*
- *Because of the calculation of the normal distance from shock, the sum of `DIST_1` and of `DIST_2` must be sufficiently large compared to the supposed amplitude of the relative displacement of the nodes of shocks (cf [R5.06.03]).*

### 3.10.1.9 Operands `SOUS_STRUC_1/SOUS_STRUC_2`

◇ `SOUS_STRUC_1 = ss1`

Name of the substructure which contains the node of shock informing the keyword `NOEUD_1` (or `GROUP_NO_1`).

◇ `SOUS_STRUC_2 = ss2`

Name of the substructure which contains the node of shock informing the keyword `NOEUD_2` (or `GROUP_NO_2`).

### 3.10.1.10 Operand **REFERENCE MARK**

◇ `REFERENCE MARK = reference mark`

Specify the reference mark in which the position of the obstacle is defined.

/ `'TOTAL'`

The absolute position of the obstacle is defined independently of rotations and translations to which the various substructures are subjected.

/ `nom_sst`

Name of a substructure.

The position and the normal of the obstacle are given in the reference mark used to define the coordinates of the nodes of the substructure `nom_sst`, the position and the normal finales of the obstacle being the result of rotation and the translation to which is subjected under - structure.

### 3.10.1.11 Operand **RIGI\_NOR**

◆ `RIGI_NOR = kN`

Value of the normal rigidity of shock (unit  $N/m$  in USI).

### 3.10.1.12 Operand **AMOR\_NOR**

◇ `AMOR_NOR = Cn`

Value of the normal damping of shock (unit  $N\ m/s$  in USI).

### 3.10.1.13 Operand **RIGI\_TAN**

◆ `RIGI_TAN = kt`

Value of the tangential rigidity of shock (unit  $N/m$  in USI).

## 3.10.1.14 Operand AMOR\_TAN

- ◇ AMOR\_TAN = ct  
Value of the tangential damping of shock (unit  $N m/s$  in USI).

### Note:

If a stiffness  $k_t$  is specified and that the keyword AMOR\_TAN is absent, the code calculates a damping optimized in order to minimize the residual oscillations in adherence according to the formula:

$$c_t = 2 \sqrt{(k_i + k_t) m_i} - 2 \xi_i \sqrt{k_i m_i}$$

where  $I$  am the index of the dominating mode in the answer of the structure.

## 3.10.1.15 Operand FRICTION

- ◇ FRICTION = / 'NOT'  
The condition of contact is without friction.
  - / 'COULOMB'
    - ◆ COULOMB = driven  
Value of the coefficient of friction (without dimension).
  - / 'COULOMB\_STAT\_DYNA'
    - ◆ COULOMB\_STAT = driven  
Value of the adhesion coefficient (without dimension).
    - ◆ COULOMB\_DYNA = mud  
Value of the coefficient of friction (without dimension).

## 3.10.2 Not localised linearities of fissured rotor: ROTOR\_FISS

The operands following are specific to transitory calculation with localised non-linearity of type "rotor fissured" for calculations of line of trees modelled in 1D (beam). The crack is considered completely included in a section of the rotor. It is delimited by two distinct nodes but confused coordinates, one connected to the left part of the line of trees, the other with the right part. They respectively represent the left lip and the right lip of the crack.

The behavior of the crack is given by a law of stiffness of crack and its derivative. This law is in addition given by calculations 3D into quasi-static. It does not depend on the geometry of the rotor but only of and the coefficient fissure shape of dimension.

- ◇ ROTOR\_FISS = \_F (
  - / ◆ /NOEUD\_G = left lip of the crack
  - /GROUP\_NO\_G = group of node naming the left lip of the crack
  - ◆ /NOEUD\_D = right lip of the crack
  - /GROUP\_NO\_D = group of node naming the left lip of the crack
  - ◆ ANGL\_INIT = initial angle of the bottom of crack compared to its definition in the law of behavior of crack [by default 0.0]
  - ◇ ANGL\_ROTA = function giving the imposed law of angular position of the bottom of crack compared to its definition in the law of behavior of crack (transients speed)
  - ◆ K\_PHI = law of behavior in stiffness of the crack
  - ◆ DK\_DPFI = derived from the law of behavior in stiffness)

### Orientation of the axis of the rotor:

To respect the trigonometrical direction of rotation, it is important to direct the rotor well: the axis of the rotor is automatically directed by the crack, while going from the left edge towards the edge right-hand side of the crack.

## 3.11 Keyword VERI\_CHOC

Keyword which makes it possible to evaluate a posteriori, the aptitude of the modal base to represent the impacts correctly.

If VERI\_CHOC is present, one calculates in each node of shock and for each mode, the rate of

reconstitution of the static solution:  $t_s = K_{statique} \sum_{i=1}^n \frac{({}^T \Phi_i \cdot F_{impo})^2}{k_i}$  and, for information, the rate of

reconstitution of the shearing action:  $t_N = \sum_{i=1}^n \frac{{}^T \Phi_i \cdot F_{impo}}{k_i} \cdot ({}^T F_{impo} \cdot K \cdot \Phi_i)$ . One calculates then the values cumulated on the whole of the modes which constitute the modal base used.

It is checked that the report of the flexibility neglected (static flexibility minus reconstituted static flexibility) on the flexibility of shock remains lower than the value given by the operand THRESHOLD (THRESHOLD 0.5 by default is worth) if not:

- if STOP\_CRITERE = 'YES' the execution of the program is stopped (it is the case by default);
- if STOP\_CRITERE = 'NOT' one continues the execution of the program with emission of an alarm.

### Note:

- This functionality is available only for obstacles of the type *plan* or *bi\_plan*.
- If the rate of reconstitution of the static solution is lower than the value of the threshold, one advises with the user to supplement the modal base by the local modes at the points of shock which have an important local flexibility.
- The formula is not applicable in the event of static modes (noninvertible matrix of rigidity). Calculation continues then without checking of the criteria of shock and the user is informed by it.

## 3.12 Keyword ANTI\_SISM

The keyword ANTI\_SISM is incompatible with a calculation by dynamic under-structuring. It makes it possible to calculate the nonlinear force which exists if an antiseismic device is placed between the two antagonistic nodes whose names are specified by the keywords (NOEUD\_1 or GROUP\_NO\_1 and NOEUD\_2 or GROUP\_NO\_2):

$$F_D = K_2 x + \frac{(K_1 - K_2)x}{\sqrt{1 + \left(K_1 \frac{x}{P_y}\right)^2}} + C \operatorname{sign}(\dot{x}) \left| \dot{x} \frac{x}{x_{max}} \right|^\alpha$$

- ◇ RIGI\_K1, RIGI\_K2, SEUIL\_FX, C, PUIS\_ALPHA and DX\_MAX  
Parameters of the force due to the presence of an antiseismic device.

By way of an example, the values of the parameters for an antiseismic device of BULGE type are:

$$K1 = 6.E + 06 \text{ N/m}, \quad K2 = 0.53 E + 06 \text{ N/m}, \quad P_y = 1200., \quad C = 0.07 E + 05 \text{ Nm/s}, \\ \alpha = 0.2 \text{ and } x_{max} = 0.03 \text{ m} \text{ (if the problem is posed in USI).}$$

## 3.13 Keyword DIS\_VISC

It is a nonlinear viscoelastic behavior between two nodes, cf. [R5.03.17]. This behavior affects only the degree of freedom DX room of the element. Direction x local from the element goes from node 1 to node 2.

Note: The results concerning the effort, viscous and relative displacements between the two nodes, as well as the dissipation of the non-linear device can be saved in a directly exploitable file by the orders of Code\_Aster . The file design is done by the single-ended spanner word `UNITE_DIS_VISC` who is under the key word `IMPRESSION` order.

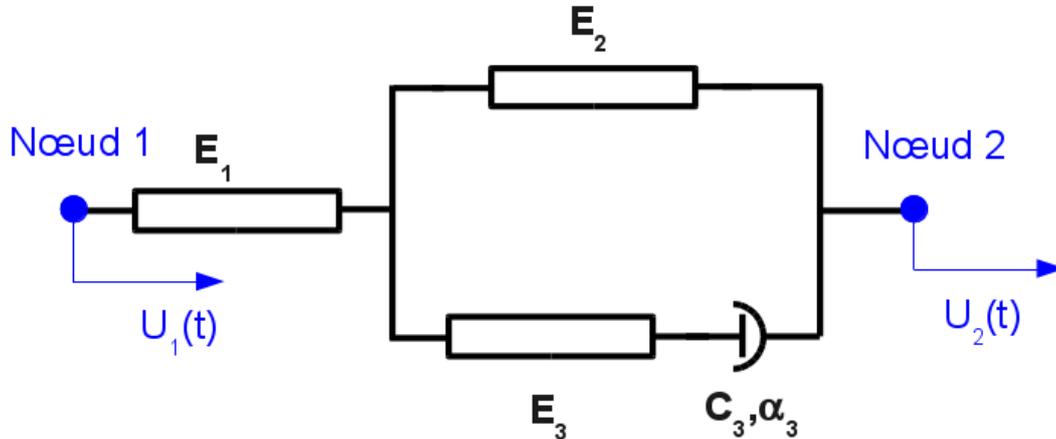


Figure 3.13-a : diagram of the device.

### 3.13.1 Syntax

```

◇ DIS_VISC = _F (
  ◆ / NOEUD_1           = no1,           [node]
    /GROUP_NO_1       = grno1,         [group_no]
  ◆ /NOEUD_2           = no2,           [node]
    /GROUP_NO_2       = grno2,         [group_no]

  ◆ / K1               = k1,           [R]
    / UNSUR_K1        = usk1,         [R]
  ◆ / K2               = k2,           [R]
    / UNSUR_K2        = usk2,         [R]
  ◆ / K3               = k3,           [R]
    / UNSUR_K3        = usk3,         [R]
  ◆ C                  = C,           [R]
  ◆ PUIS_ALPHA        = /0.5          [defect]
                                /alpha, [R]

◇ ITER_INTE_MAXI     = /20            [defect]
                                /iter    [I]
◇ RESI_INTE_RELA     = /1.0E-06      [defect]
                                /resi    [R]
)
    
```

### 3.13.2 Operands related to the position of the device

- ◆ NOEUD\_1 or GROUP\_NO\_1
- ◆ NOEUD\_2 or GROUP\_NO\_2

Nodes or name of the groups of node of the structure between which the non-linear device is placed. If one is used `GROUP_NO` to define one of the anchor points of the device, the group of node should contain one node.

During calculation, it is necessary to know the direction of the non-linear device because it functions only in its axis. It is necessary thus that the distance between the two nodes is nonworthless.

### 3.13.3 Operands related to the behavior

The behavior `DIS_VISC` is a nonlinear viscoelastic rheological behavior, of type Zener extended, allowing to schematize the behavior of a uniaxial shock absorber, enters two nodes.

For the local direction  $x$  (and only that one) of the device, one provides five coefficients. Their units must be in agreement with the unit of the efforts, the unit lengths and the unit of time of the problem:

- `K1` : elastic stiffness of element 1 of the rheological model,
- `K2` : elastic stiffness of element 2 of the rheological model,
- `K3` : elastic stiffness of element 3 of the rheological model,
  
- `UNSUR_K1` : elastic flexibility of element 1 of the rheological model,
- `UNSUR_K2` : elastic flexibility of element 2 of the rheological model,
- `UNSUR_K3` : elastic flexibility of element 3 of the rheological model,
  
- `PUIS_ALPHA` : power of the viscous behavior of the element  $\alpha$ ,
- `C` : coefficient of the viscous behavior of the element.

There exist conditions to respect on the values of the coefficients so that the tangent is always defined:

$$k1 \geq 10^{-8} \quad usk1 \geq 0 \quad k3 \geq 10^{-8} \quad usk3 \geq 0 \quad usk2 \geq 10^{-8} \quad k2 \geq 0 \quad C \geq 10^{-8} \\ 10^{-8} \leq \alpha \leq 1$$

One cannot thus have at the same time  $usk1=0$ ,  $usk3=0$  and  $k2=0$  i.e. the case of the shock absorber alone.

### 3.13.4 Operands related to the convergence of the behavior of the device

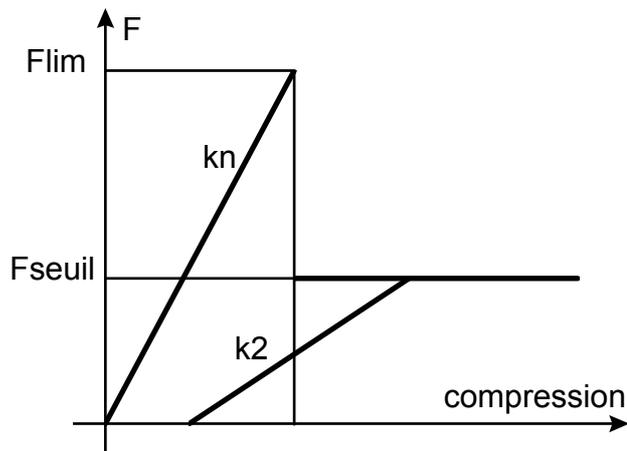
◇	<code>ITER_INTE_MAXI</code>	<code>=/20</code>	[defect]
		<code>/iter</code>	[I]
◇	<code>RESI_INTE_RELA</code>	<code>=/1.0E-06</code>	[defect]
		<code>/resi</code>	[R]

These operands have the same meaning as when they are used with the order `STAT_NON_LINE/COMPORTEMENT` [U4.51.11].

The relation of behavior `DIS_VISC` require to solve a nonlinear system by a method of Runge-Kutta of order 5 with adaptive step. The control of the algorithm (iteration count and residue) are used to test convergence and to adapt the step if need be.

## 3.14 Keyword BUCKLING

This keyword is used for the detection of possible buckling and the evaluation of the residual deformation of an element at the time of a shock between two mobile structures or a mobile structure and a fixed wall. The force of reaction at the time of a shock with taking into account of buckling can be summarized by the following diagram:



It is considered that there is buckling if the force of reaction  $F$  reached the limiting value  $F_{lim}$  defined by the user. The normal rigidity of shock after buckling  $k2$  is then different from rigidity before buckling  $kn$ .

Only operands specific to the keyword `BUCKLING` are detailed. The other keywords make it possible to define the places of shock and are identical to the operands of the keyword `SHOCK`.

- ◇ `FNOR_CRIT = film`  
Normal force limits which involves the buckling of the structure.
- ◇ `FNOR_POST_FL = fseuil`  
Normal force limits after buckling which causes a residual deformation of the structure.
- ◇ `RIGI_NOR_POST_FL = k2`  
Value of normal rigidity after buckling.

## 3.15 Keyword `RELA_EFFO_DEPL`

- ◇ `RELA_EFFO_DEPL`  
Keyword factor allowing to define a relation force-displacement or moment - rotation on a degree of freedom given in the shape of a nonlinear curve.

### 3.15.1 Operand `NODE`

- ◆ `NODE = No`  
Name of the node of the structure to which the relation relates.

### 3.15.2 Operand `SOUS_STRUC`

- ◇ `SOUS_STRUC = ss`  
Name of the substructure containing the node informing the operand `NODE`.

### 3.15.3 Operand `NOM_CMP`

- ◇ `NOM_CMP = nomcmp`  
Name of the component of the node of the structure to which the relation relates.

### 3.15.4 Operand `RELATION`

- ◆ `RELATION = F`  
Name of the nonlinear function.

The nonlinear relation must be defined on  $]-\infty, \infty[$ . The non-linear phase in postprocessings corresponds to the beach of moments when the nonlinear relation was not-worthless.

The equilibrium equation, for a structure subjected to a horizontal acceleration of ground  $a_x$  in the direction  $x$ , and having terms of correction coming from non-linearities, is written:

$$M \ddot{x} + C \dot{x} + K x = - M a_x + F_c$$

where  $F_c$  is the corrective force due to nonthe linearity of the ground. It can be, for example, defined by the following relation (cf case test SDND103):

$$F_c = k x - f(x)$$

with:

$$\text{if } x \geq x_0, f(x) = k \left( \frac{|x|}{x_0} \right) x.$$

In example Ci above, one thus imposes, under the operand RELATION the function:

$$F_c(x) = \frac{k}{x_0} x [|x| - x_0] \quad \text{for } |x| > x_0$$
$$F_c(x) = 0 \quad \text{for } |x| \leq x_0$$

## 3.16 Keyword RELA\_EFFO\_VITE

◇ RELA\_EFFO\_VITE

Keyword factor allowing to define a relation force-speed on a degree of freedom of a node given in the form of a nonlinear function.

Operands NODE, SOUS\_STRUC, NOM\_CMP and RELATION the same direction for the keywords has RELA\_EFFO\_DEPL and RELA\_EFFO\_VITE. They are thus not detailed in this paragraph.

## 3.17 Keyword COUPLAGE\_EDYOS

◇ COUPLAGE\_EDYOS

Obligatory keyword factor at the time of the coupling with code EDYOS to calculate the answer of revolving machines on non-linear stages. The keyword factor PALIER\_EDYOS must then also be well informed (cf. the following paragraph).

### 3.17.1 Operand LIVESE\_ROTA

◆ VITE\_ROTA = vrot

Definition number of revolutions of the rotor out of turns per minute.

### 3.17.2 Operand PAS\_TPS\_EDYOS

◆ PAS\_TPS\_EDYOS = dtedyos

Pas de initial time for code EDYOS.

## 3.18 Keyword PALIER\_EDYOS

◇ PALIER\_EDYOS

Second obligatory keyword factor at the time of the coupling with code EDYOS. It makes it possible to define the position and the type of the non-linear stages whose answers will be calculated by EDYOS.

The data to be specified, for each non-linear stage, are:

- position of the stage (either by the name of the node of the grid, or by the name of the group containing this node alone),
- type of selected stage (thus corresponding to a particular model EDYOS).

These data can be entered according to two operating processes.

That is to say all the data are in an external textual file, of which the logical unit will be specified by the keyword `UNIT`.

Either one directly returns the data in the command file, *via* `GROUP_NO` or `NODE` and `TYPE_EDYOS`.

### 3.18.1 Operand `UNIT`

- ♦ / `UNIT = uled`

Definition of the logical unit of the external textual file which contains the definition of the positions and the types of all the non-linear stages. Here an example of this file:

```
2
1 NOE0   PACONL
2 NOE10  PACONL
```

The first line indicates the full number of non-linear stages, here two.

Then, each line corresponds to a stage, with three parameters: number (arbitrary) of stage, position of the stage (name of the node or the group of corresponding node) and model of stage EDYOS (here `PACONL`). For the second argument, the code will seek in all the groups of nodes of the grid, then if the name indicated is not found, research continues in the names of nodes and in the event of failure, an error message is transmitted and precise that the name indicated by the user could not be found. The code stops then in fatal error.

### 3.18.2 Operand `GROUP_NO`

- ♦ / `GROUP_NO = grnoed`

Group of node containing one node and which corresponds to the position of the non-linear stage considered.

### 3.18.3 Operand `NODE`

- ♦ / `NODE = noed`

Name of the node which corresponds to the position of the non-linear stage considered. One classically advises to privilege the use of `GROUP_NO` with `NODE` for reasons of more practical naming.

### 3.18.4 Operand `TYPE_EDYOS`

- ♦ / `TYPE_EDYOS = / 'PAPANL',`  
`/ 'PAFINL',`  
`/ 'PACONL',`  
`/ 'PAHYNL',`

Name of the model of stage associated, according to the terminology of code EDYOS. Only the following types of non-linear stages are authorized:

- `PAPANL` : mobile pedestal bearings,
- `PAFINL` : fixed pedestal bearing,
- `PACONL` : stage with taking into account of possibilities of contact,
- `PAHYNL` : stage hybrids (hydrodynamic/hydrostatic with pockets of rising).

## 3.19 Keyword FILING

- ◇ FILING  
Keyword factor defining filing.

### Note:

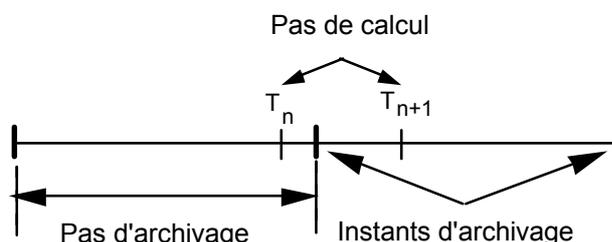
For the diagrams of integration of the Runge-Kutta type, filing is done in a systematic way over every moment of calculation. Thus, values given in the operands `LIST_ARCH`, `INST` and `PAS_ARCH` are not taken into account.

### 3.19.1 Operand LIST\_ARCH/INST

- ◇ / LIST\_INST = l\_arch  
List of entireties defining the moments of calculation for which the solution must be filed in the concept result `tran_gene`.
- ◇ / INST  
Moments of calculation for which the solution must be filed in the concept result `tran_gene`.

### 3.19.2 Operand PAS\_ARCH

- ◇ PAS\_ARCH = ipa
- Methods 'EULER', 'DEVOGE', 'NEWMARK', 'ITMI':  
Entirety defining the periodicity of filing of the solution of transitory calculation in the concept result `tran_gene`.  
If `ipa = 5` all 5 pas de calculation are filed.  
Whatever the option of filing chosen, one files the last step of time and all the associated fields to allow possible recovery.  
By default one files all the steps of calculation.
- Methods 'ADAPT\_ORDRE1' and 'ADAPT\_ORDRE2':  
Entirety which makes it possible to calculate the interval between two moments of filing in the concept result, equal to `PAS_ARCH*PAS`. With this convention, the step of filing is always higher or equal to the maximum step used by calculation.  
  
With a variable step, the moments of filing do not correspond exactly to steps of calculation. The algorithm thus files the sizes with the steps of calculation closest to the moments of filing indicated by the user (in  $T_n$  on this diagram):



### 3.19.3 Operand CRITERION

- ◇ CRITERION =  
Indicate with which precision the research of the moment to be filed must be done:  
'RELATIVE' : interval of research [(1-prec) .instant, (1+prec) .instant]  
'ABSOLUTE' : interval of research [moment-prec, instant+prec]  
The value by default of the search criterion is 'RELATIVE'.

## 3.19.4 Operand PRECISION

◇ PRECISION = / 1.E-06 [DEFECT]  
/ prec [R]

Indicate with which precision the research of the moment to be filed must be done.

## 3.20 Operand INFORMATION

◇ INFORMATION = imp

Entirety allowing to specify the level of impression in the file MESSAGE.

If INFO=1, one prints following information in the file MESSAGE :

<I> <nom of the routine where information suivantes> is written

If <I> <MDTR74>, it is pointed out that it is a transitory calculation on modal basis  
"classical", if not <I> <SSDT74> it is a transitory calculation on modal basis by dynamic  
under-structuring.

<----->

Calculation by modal superposition

-----

! the base of projection is one >type of the base of projection<  
! Nb of equations is : Nb  
! the method used is : >name of the method of integration <  
! the base used is : >name of the modal base <  
! Nb of basic vectors is : nbb

! the step of initial time is : step value of initial time

! Nb of step of archive is : nba

! the number of place (X) of shock is: nbchoc

(beginning of information specific to the adaptive diagrams)

! many points not period : NLP

! coefficient of increase of the step of time : cmp

! coefficient of division of the step of time : Cdp

! pas de minimal time : dtmini

! pas de maximum time : dtmaxi

! maximum number of reductions of the step : nbred

! variable minimal speed : >method of calculation the speed of référence<  
(end of information specific to the adaptive diagrams)

! many steps of calculation are : nbc

! The step of time of calculation is : step value of computing time

! the number of RELA\_EFFO\_DEPL is : nbrelaed

(only if the number of relations is nonnull)

! the number of RELA\_EFFO\_VITE is : nbrelaev

(only if the number of relations is nonnull)

-----

If INFORMATION : 2, one prints, besides written information if INFORMATION is worth 1, following  
information in the file MESSAGE :

For each obstacle:

- The number and type of the obstacle;
- The name and coordinates in the total reference mark of the node of shock (of the nodes of shock in the case of a shock between mobile structures);
- Orientation, in the total reference mark, of the normal to the obstacle;
- The value of the angle of gimlet;
- The value of the initial game;

And for each node of shock and each mode, the number of the mode, values of the local stiffnesses of shock and the rate of local flexibility and the local flexibility.

One also prints at the end, for each node of shock:

```
RATE OF RESTIT FLEXIBILITY: 9.9539E-01 that is to say 99.53% of local flexibility;  
RATE OF RESTIT SHEARING ACTION: 1.8979E-02 that is to say 1.89% of the shearing  
action.
```

One prints these quantity overall for the whole of the modes and each mode.

One prints moreover:

- for each node of shock, local the flexibility reports on flexibility of shock and static flexibility minus local flexibility on flexibility of shock,
- for each mode, its participation on the deformations statics in the nodes of shock. It is worth the report amongst conditioning of the matrix closed by the modal vector and the static deformations on the number of conditioning of the matrix of the static deformations.

## 3.21 Operand IMPRESSION

◇ IMPRESSION

Keyword factor which makes it possible to print in the file `RESULT` sizes, nonprintable by an operator of impression, such as local displacement, local speed, forces of contact to the nodes of shock and the value cumulated on all the modes of the modal base of projection of the rate of reconstitution of the static solution.

### 3.21.1 Operands ALL/LEVEL

The keyword `LEVEL` allows to print one or more table (X) among `'DEPL_LOC'`, `'VITE_LOC'`, `'FORC_LOC'` and `'TAUX_CHOC'`. With `ALL = 'YES'` (value by default), the four tables are printed.

### 3.21.2 Operands INST\_INIT/INST\_FIN

These two keywords make it possible to the user to filter the impressions in each loop on the steps of time.

### 3.21.3 Operand UNITE\_DIS\_VISC

◇ `UNITE_DIS_VISC = links`

The results concerning the effort, viscous and relative displacements between the two nodes, as well as the dissipation of the non-linear device can be saved in a directly exploitable file by the orders of `Code_Aster`.

## 3.22 Operand TITLE

◇ `TITLE = title`

Title of the structure of data result [U4.03.01].

## 4 Production run

### 4.1 Checking on the matrices

In the case of a calculation by modal recombination, one checks that the generalized matrices result quite from a projection on a common basis and with the same number of basic vectors. In the case of a calculation by dynamic under-structuring, one checks that the generalized matrices result quite from the same generalized classification.

### 4.2 Checking and council on the choice of the step of time for the diagrams EULER, DEVOGE and NEWMARK :

One makes sure that the step of selected time checks the stability conditions of the digital diagram (criterion of CFL):

- in the case of NEWMARK, stability is always assured but the going beyond the criterion can induce a lack of precision on the result and is announced by a message; calculation continues (with the risk to produce a not very precise or false result).
- in the case of diagrams of EULER and DEVOGE, if the operand VERI\_PAS is worth 'YES' (value by default), the execution is stopped, a step of minimum time is proposed. If the operand VERI\_PAS is worth 'NOT' or if it is about a diagram adaptive, a message of alarm is transmitted and calculation continues (with the risk to produce a not very precise or false result).

In a transitory analysis without non-linearity, it should be taken care that the step of time is such as:

$$dt < 0,1 / f_n \text{ for NEWMARK and DEVOGE}$$

$$dt < 0,05 / f_n \text{ for EULER}$$

$f_n$  being the highest frequency of the modes of the modal base considered.

**Note:**

*It is mentioned that with nonlocalised linearities the step of selected time must be sometimes much lower than this advised value.*

### 4.3 Production run for the methods 'ADAPT\_ORDRE1' and 'ADAPT\_ORDRE2' :

The execution is stopped when the step of time reaches a minimal step equal to NOT X PAS\_LIMI\_RELA.

**Note:**

*The diagram of the centered differences does not restore in an exact way the own pulsations of a system, which leads to important miscalculations in the two following cases:*

- *Calculation of one very a large number of periods of free oscillations;*
- *Calculation of the oscillations of a system very slightly deadened ( $\xi < 10^{-3}$ ) excited on a frequency of resonance.*

*In these two cases, it is often necessary to increase the parameter NB\_POIN\_PERIODE .*

*Methods 'ADAPT\_ORDRE1' and 'ADAPT\_ORDRE2' can be used under-structuring.*

*The step of time can be recovered by the operator RECU\_FONCTION , with following syntax:*

```
not = RECU_FONCTION (  
    RESU_GENE = dynamoda  
    NOM_CHAM = 'PTEM'  
    ... )
```

## 4.4 Production run for the method 'ITMI'

The execution is stopped:

- when the duration of excitation chosen by the user is incompatible with the desired time of simulation (mode established + simulation after obtaining the established mode). In this case, the user is informed with precision of the minimum time of excitation necessary for his calculation,
- when the algorithm does not succeed in finding a solution converged at the time of the diagonalisation of the matrix of stiffness,
- when the phases of transition flight/shock cannot be given with a sufficient precision.