

Operator DYNA_LINE_TRAN

1 Goal

To calculate the transitory dynamic response to an unspecified temporal excitation.

The temporal loading must be given in the form of a linear combination of constant vectors forces assembled in time. They can be provided directly in the form of assembled vectors or loads which will be assembled in the algorithm.

Only the coefficients of the linear combination are function of time.

The implicit methods of integration available are Wilson-theta and NEWMARK, and the explicit methods of integration available are the diagram with the differences centered, and a version with adaptive step of this same diagram.

Moments of filing can be specified.

Product a concept result of the type `dyna_trans`.

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Code_Aster

Version
default

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2 Syntax

```
dyn [dyna_trans] = DYNA_LINE_TRAN

(
  ◇ reuse = dyn,
  ◇ MODEL = Mo, [model]
  ◇ CHAM_MATER = chmat, [cham_mater]
  ◇ CARA_ELEM = carac, [cara_elem]
  ◆ MATR_MASS = m, [matr_asse_DEPL_R]
  ◆ MATR_RIGI = K, [matr_asse_DEPL_R]
  ◇ MATR_AMOR = C, [matr_asse_DEPL_R]
  ◇ MODE_STAT = modestat, [mode_meca]
  ◇ SCHEMA_TEMPS = _F (
    ◆ DIAGRAM = ( | 'NEWMARK', [DEFECT]
                  | 'WILSON',
                  | 'DIFF_CENTRE'
                  | 'ADAPT_ORDRE2'
                ),
    ◇ BETA = /0.25, [DEFECT]
      /beta, [R]
    ◇ GAMMA = /0.5, [DEFECT]
      /gamma, [R]
    ◇ THETA = /1.4, [DEFECT]
      /th, [R]
  ),
  ◇ / ETAT_INIT = _F (
    ◆ / RESULT = Dy, [dyna_trans]

    ◇ / NUME_ORDRE = nuord, [I]
      / INST_INIT = to, [R]
    ◇ / CRITERION = 'RELATIVE', [DEFECT]
      ◇ PRECISION = / 1.E-06, [DEFECT]
        / prec, [R]
      / CRITERION = 'ABSOLUTE',
        ◆ PRECISION = prec, [R]
  ) / DEPL = depl, [cham_no_sdaster]
    QUICKLY = quickly,

[cham_no_sdaster]
    ACCE = acce, [cham_no_sdaster]
  ),
  ◇ EXCIT = _F (
    ◆ / LOAD = chi, [char_meca]
      ◇ FONC_MULT = fi, [function]
      / VECT_ASSE = goes,

[cham_no_sdaster]
      ◇ / COEF_MULT = have, [R]
        / FONC_MULT = fi, [function]
        / DEPL = depl, [function]
        QUICKLY = quickly, [function]
        ACCE = acce, [function]
    ◇ MULT_APPUI = / 'YES',
      / 'NOT', [DEFECT]
    ◇ DIRECTION = (d1, d2, d3), [l_R]
    ◇ NODE = lno, [l_noeud]
    ◇ GROUP_NO = lgrno, [l_gr_noeud]
  ),
  ◇ EXCIT_RESU = _F (
```

```

    ◆ RESULT = resuforc, [dyna_trans]
    ◆ COEF_MULT = have, [R]
    ),
◇ AMOR_MODAL =_F (
    ◆ AMOR_REDUIT= l_amor, [l_R]
    ◆ MODE_MECA = mode, [mode_meca]
    ◇ NB_MODE = / nbmode, [I]
    / 9999, [DEFECT]
    ),
◇ SOLVEUR =_F (see the document [U4.50.01] and the paragraph
corresponding in present Doc.),
    ◆ INCREMENT =_F (
    ◆ / LIST_INST = litps, [listr8]
    / NOT = dt, [R]
    ◇ INST_INIT = Ti, [R]
    ◇ / INST_FIN= tf, [R]
    / NUME_FIN= nufin, [I]

    ◇ PAS_CALCUL =/ 1, [DEFECT]
    / ipas, [I]

    ◇ VITE_MIN =/'MAXIMUM',
    /'NORM', [DEFECT]
    ◇ COEF_MULT_PAS =/ cmp, [R]
    / 1.1, [DEFECT]
    ◇ COEF_DIVI_PAS =/ cdp, [R]
    / 1.3334, [DEFECT]
    ◇ PAS_LIMI_RELA =/ plr, [R]
    / 1.D-06, [DEFECT]
    ◇ NB_POIN_PERIODE =/Np, [I]
    / 50, [DEFECT]

    ◇ NMAX_ITER_PAS = nip, [I]
    16, [DEFECT]
    ◇ NOT_MINIS = dtmin, [R]
    ),
◇ ENERGY = _F ()

◇ 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]
    ◇ CHAM_EXCLU = ( | 'DEPL',
    | 'QUICKLY',
    | 'ACCE'
    ),
    ),
◇ TITLE = title, [l_Kn]
◇ INFORMATION = / 1,
/ 2,
```

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)

3 Equations of behaviour under transitory excitation

The operator carries out the direct temporal integration of a transitory linear mechanical problem of the form:

$$\mathbf{M}\ddot{\mathbf{x}} + \mathbf{C}\dot{\mathbf{x}} + \mathbf{K}\mathbf{x} = \sum_i \alpha_i(t) \mathbf{F}_i(\mathbf{x})$$

where matrices $\mathbf{M}, \mathbf{C}, \mathbf{K}$ are the assembled real matrices of the problem finite elements (respectively) of mass, damping and rigidity of the system.

α_i are functions of time (cf. `DEFI_FONCTION` [U4.31.02]) and them \mathbf{F}_i resulting from loadings in imposed force (cf are assembled vectors. `AFFE_CHAR_MECA` [U4.44.01]); they can be provided directly in the form of assembled vectors or loads which will be assembled in the algorithm.

The solution $(\mathbf{X}, \dot{\mathbf{X}}, \ddot{\mathbf{X}})$ is calculated on a temporal discretization t_i interval of study specified by the user.

4 Operands

4.1 Operand `MODEL`

◇ `MODEL = Mo`

Name of the model whose elements are the object of dynamic calculation.

This operand is obligatory when one applies an excitation of the type charges with the keyword `EXCIT` (cf [§4.7]).

4.2 Operand `CHAM_MATER`

◇ `CHAM_MATER = chmat`

Name of the affected material field on the model `Mo`, necessary when one applies an excitation of the type charges with the keyword `EXCIT`.

4.3 Operand `CARA_ELEM`

◇ `CARA_ELEM = carac`

Name of the characteristics of the elements of beam, hull etc, necessary when one applies an excitation of the type charges with the keyword `EXCIT`.

4.4 Matrices of the problem

◆ `MATR_MASS = m`

Concept stamps assembled of type `matr_asse_DEPL_R` corresponding to the matrix of mass of the system.

◆ `MATR_RIGI = K`

Concept stamps assembled of type `matr_asse_DEPL_R` corresponding to the matrix of rigidity of the system.

◇ `MATR_AMOR = C`

Concept stamps assembled of type `matr_asse_DEPL_R` corresponding to the matrix of damping of the system.

N.B: The three matrices must be based on same classification and be built with the same mode of storage. It is true also of a matrix of damping built like linear combination of the matrices of rigidity and mass by the method of Rayleigh: to use the matrix of the matrix of mass supplements to build the matrix of damping and the matrix of diagonal mass (explicit diagrams such as `DIFF_CENTRE` or `ADAPT`) for integration in time can lead to a digital instability.

4.5 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`.

4.5.1 Operand `DIAGRAM`

| ' `NEWMARK` '

Implicit diagram of integration of type `NEWMARK`. It is the diagram by default for the transitory analysis on physical basis.

One can specify the parameters of integration β and γ :

◇ `BETA = beta`

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

◇ `GAMMA = gamm`

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

See [R5.05.02] for the choice of other values.

| ' `WILSON` '

Implicit diagram of integration of type `WILSON`. With this diagram one can inform:

◇ `THETA = HT`

Value of the parameter θ for the method of `WILSON`. By default $\theta = 1,4$.

This diagram should not be used when one imposes nonworthless displacements via an assembled vector. See [R5.05.02].

| ' `DIFF_CENTRE` '

Diagram of integration clarifies by centered differences. The use of this diagram imposes certain enumerated restrictions of use on [§6.3]. The theoretical description of the diagram is made in [feeding-bottle 2].

| ' `ADAPT_ORDRE2` '

Diagram of integration clarifies with step of adaptive time, alternative of the diagram of the centered differences. The use of this diagram imposes certain enumerated restrictions of use on [§6.3] (see [feeding-bottle 2]).

Nota bene

One cannot use the diagrams **explicit** (`DIFF_CENTRE` , `ADAPT_ORDRE2`) with **elements of plate and hull** (except `SHB`).

4.6 Keyword ETAT_INIT

This functionality allows a continuation of a transitory calculation, by taking as initial state a result got by a preceding calculation with DYNA_LINE_TRAN. It also makes it possible to define initial conditions of fields type in the nodes.

Nota bene

For the diagrams of a higher nature (*NEWMARK* or *WILSON*), initial acceleration (*acce_init*) play an important role in the initialization of the diagram.

4.6.1 Operands RESULT

◆ / RESULT = Dy

Concept of the type *dyna_trans* resulting from a preceding calculation with DYNA_LINE_TRAN, and defining the initial conditions for new calculation.

4.6.2 Operands DEPL/ VITE/ACCE

/ DEPL = C

Concept corresponding to initial displacements (field with the nodes of size *DEPL_R*).

QUICKLY = vo

Concept corresponding at the initial speeds (field with the nodes of size *DEPL_R*).

ACCE = ao

Concept corresponding to initial accelerations (field with the nodes of size *DEPL_R*).

If the key word is present, one uses the field of acceleration entered to initialize the various diagrams of integration in time according to the algorithms described in the document [R5.05.02].

If it is absent one calculates an initial acceleration by the following formula:

$$M.a_o = F_{ext}(t = t_o) - C.v_o - K.x_o$$

Remarque important:

When the initial state of the dynamic system is defined by fields of DEPL, QUICKLY, and/or ACCE, the components of these fields which were not explicitly indicated during the creation of the fields are considered worthless during transitory dynamic calculation.

4.6.3 Operands NUME_ORDRE/ INST_INIT

◇ / NUME_ORDRE = nuord

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

/ INST_INIT = to

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

In the absence of NUME_ORDRE and INST_INIT, the moment of recovery is taken equal to the last moment of filed preceding calculation.

4.6.4 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 value by default of the search criterion is 'RELATIVE'.

4.6.5 Operand PRECISION

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

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

4.7 Keyword EXCIT

◇ EXCIT =

Operand allowing to define several space-time excitations. Either by indicating a vector assembled correspondent to a loading, or of the loads which will lead to the calculation and the assembly of a second member. The assembled vector can be associated with a function with temporal evolution or a constant multiplying coefficient.

The total loading is the sum of the loadings defined by all the occurrences of the keyword EXCIT (cf [§4.7.2]).

4.7.1 Operands VECT_ASSE / LOAD

◆ / VECT_ASSE = vecti

Vector assembled correspondent with a loading (concept of the type cham_no_DEPL_R).

◇ / COEF_MULT = Ci

Multiplicative coefficient of the assembled vector vecti.

/ FONC_MULT = α_i

See [§4.7.2].

/ LOAD = chi

chi is the loading possibly comprising the evolution of a field of temperature specified by i ème occurrence of EXCIT.

See [§4.7.2].

4.7.2 Operand FONC_MULT

◇ FONC_MULT = α_i

α_i is the multiplicative function of the time of the assembled vector or loading specified with i ème occurrence of EXCIT.

The loading **ch** and boundary conditions for n occurrences of the keyword factor EXCIT are:

$$\mathbf{ch}(t) = \sum_{i=1}^n \alpha_i(t) \mathbf{ch}_i$$

The fields of temperature are not multiplied by α_i in thermomechanical analysis.

Notice important:

The boundary conditions of type displacement imposed not no one can be imposed with an assembled vector or a load ; it is then necessary to use the diagram of Newmark imperatively .

4.7.3 Operands MULTI_APPUI / ACCE / QUICKLY / DEPL / DIRECTION / NODE / GROUP_NO/MODE_STAT

In the case of an excitation multi-supports (`MULT_APPUI = 'YES'`), the other operands have exactly the same meaning as in the keyword factor `EXCIT` of the operator `DYNA_TRAN_MODAL` [U4.53.21].

4.8 Keyword EXCIT_RESU

Keyword allowing to define several complements of loading in the form of a transitory evolution of assembled vectors second members.

4.9 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 $-C\dot{X}$.

N.B. : This way of introducing modal damping into a problem calculated on physical basis can reduce the properties of stability of the diagrams in time. In particular for the diagram of integration 'NEWMARK' it can result in reducing the step of time compared to the step of time without damping to avoid digital divergences.

4.9.1 Operands MODE_MECA / AMOR_REDUIT / NB_MODE

- ◆ `MODE_MECA` = mode
- ◆ `AMOR_REDUIT` = l_amor
- ◇ `NB_MODE` = nbmode

The concept mode of the type `mode_meca` (entered by the operand `MODE_MECA`) represent the base of modes precalculated on which one breaks up modal damping. This base must imperatively have the same profile of classification as that of the dynamic system defined by the parameters of the keyword `SOLVEUR` [§4.11]. It is possible to truncate the modal base with a number of modes defined by `NB_MODE`. Failing this, one takes all the modes of the modal base.

Modal depreciation in reduced form is given in the form of a list of realities of which the number of terms is lower or equal to the number of modes taken into account. If the number of terms of the list is strictly lower, one extends this list with the value of his last term until its size reaches the number of calculated modes.

4.10 Keyword ENERGY

- ◇ `ENERGY` = _F (...)

This keyword makes it possible to activate the calculation of the assessment of energy, its posting in the course of calculation and its storage in the table of name `PARA_CALC`. The assessment of energy can be extracted from this table using the order `RECU_TABLE` [U4.71.02].

4.11 Keyword SOLVEUR

The syntax of this keyword common to several orders is described in the document [U4.50.01]. However, it is advisable to pay attention to some singularities of the use of the solveurs in DYNA_LINE_TRAN :

The renumeration RENUM=RCMK (usable for LDLT and GCPC) modify the order of the unknown factors (NUME_EQUA), whereas the renumeration for MULT_FRONT (METIS/MDA/MD) is "internal" to the solver: the unknown factors (of the fields solutions) are arranged in the natural order of the nodes of the grid.

However, in DYNA_LINE_TRAN, the matrices being provided as starter, they have already a classification ("WITHOUT" or "RCMK") and one not always not to change this classification in DYNA_LINE_TRAN.

The various cases below are recapitulated:

1) if matrices K and M are numbered with:

- METHOD = 'MULT_FRONT' RENUM=METIS/MDA/MD
- or - METHOD = 'LDLT' RENUM=SANS

then:

- one can use in DYNA_LINE_TRAN :

- METHOD = 'MULT_FRONT' RENUM=METIS/MDA/MD
- METHOD = 'LDLT' RENUM=SANS

- one CANNOT use in DYNA_LINE_TRAN :

- METHOD = 'LDLT' RENUM=RCMK
(actually, one can do it but RCMK is ignored)

2) if matrices K and M are numbered with:

- METHOD = 'LDLT' RENUM=RCMK

then:

- one can use in DYNA_LINE_TRAN :

- METHOD = 'MULT_FRONT' RENUM=METIS/MDA/MD
- METHOD = 'LDLT' RENUM=RCMK

- one CANNOT use in DYNA_LINE_TRAN :

- METHOD = 'LDLT' RENUM=SANS
(actually, one can do it but WITHOUT is ignored)

4.12 Keyword INCREMENT

Keyword factor defining the moments of calculation.

4.12.1 Operands LIST_INST / NOT

- For the diagrams of Newmark and Wilson:

◆ / LIST_INST = l_temp

Concept lists realities of the type listr8.

List of realities defining the moments t_i of calculation of the solution

- For the diagrams of the centered differences and with pas de adaptive time:

/ NOT = dt

Indicate the step of time used by the algorithm. This keyword is obligatory for the diagram of the centered differences and the diagram adaptive and nonavailable for the diagrams of Newmark and Wilson.

For the adaptive diagram, it indicates at the same time the step of initial time and the step of maximum times used by the algorithm.

This parameter must be sufficiently weak:

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

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

4.12.2 Operands INST_INIT / INST_FIN / NUME_FIN

For the diagrams of the centered differences and with step in adaptive time:

◇ INST_INIT = Ti

In the event of recovery one uses the keyword ETAT_INIT [§4.6]: 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 under INCREMENT must thus be only used if it did not take again there of a preceding calculation.

◇ / INST_FIN = tf

Moment of end of transitory calculation. Obligatory for the diagrams of the centered differences and with step in adaptive time.

/ NUME_FIN = nufin

Number of the moment of end of calculation in LIST_INST (only for the diagrams of Newmark and Wilson).

If INST_INIT is not present, the initial moment is zero.

4.12.3 Operands VITE_MIN / COEF_MULT_PAS / COEF_DIV_PAS / PAS_LIMI_RELA / NB_POIN_PERIODE / NMAX_ITER_PAS / PAS_MINI

These operands relate to only the diagram with step of adaptive time.

◇ VITE_MIN = / 'NORM' [DEFECT]
/ 'MAXIMUM'

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

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

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

v_{min}^i can be calculated in two ways different according to the value from VITE_MIN :

'NORM' : $v_{min}^i(t_n) = \text{Max} \left(\frac{\text{Max}(\dot{x}_{n+1/2}^k, \dot{x}_{n+1/2}^l)}{100}, 10^{-15} \text{ms}^{-1} \right)$ where k and l are the degrees of freedom of comparable nature that the degree of freedom i closest to i in classification (DX or DY or DZ ...).

'MAXIMUM' : $v_{min}^i(t_n) = \text{Max}_{0 < t_p < t_n} \left(\frac{|v^i(t_p)|}{100}, 10^{-15} \text{ms}^{-1} \right)$ for the degree of freedom i .

Can be used if the order of magnitude speed does not vary too much in the course of time.

◇ COEF_MULT_PAS = cmp

Coefficient of déraffinement of the step of time (> 1) when the error is sufficiently weak:

$\Delta t_n < \frac{0.75}{Nf_{AP_n}}$ since more 5 pas consecutive $\Rightarrow \Delta t_{n+1} = \min(\text{cmp} \Delta t_n, \Delta t_{max})$

with $\Delta t_{max} = \Delta t_{initial}$

Its value by default ($\text{cmp} = 1.1$) 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 (NMAX_ITER_PAS) is not reached and that the step of minimal time is not reached:

$\Delta t_n > \frac{1}{Nf_{AP_n}}$, $Niter < Niter_{max}$ and $\Delta t_n > \text{plr} * \Delta t_{initial} \Rightarrow \Delta t_n = \frac{\Delta t_n}{\text{cdp}}$

Its value by default is of 1.3334, 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:

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

◇ 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 1à 2%) in most case.

◇ NMAX_ITER_PAS

Maximum number of reductions of the step of time per step of calculation:

if $err > 1$ and $N_{iter} < N_{iter,max}$: $\Delta t_n = \text{cdp} * \Delta t_n$

It is by default equal to 16, which limits the coefficient of reduction of the step to $(1/1,33)^{16} = 10^{-2}$ by iteration. 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.

◇ 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`.

4.13 Keyword **FILING**

◇ `FILING =`

Keyword factor defining filing. In the absence of this keyword factor, all the steps of time are filed.

Whatever the option of filing chosen, one files the last step of time and all the associated fields to allow a possible continuation.

4.13.1 Operands **LIST_INST/INST**

◇ `/ LIST_INST = list`

List of realities defining the moments of calculation for which the solution must be filed in the concept result `dyna_tran`.

◇ `/ INST`

Moments of calculation for which the solution must be filed in the concept result `dyna_tran`.

4.13.2 Operand **PAS_ARCH**

`/ PAS_ARCH = ipa`

Entirety defining the periodicity of filing of the solution of transitory calculation in the concept result `dyna_trans`.

If `ipa = 5` all 5 pas de calculation are filed.

4.13.3 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'.

4.13.4 Operand **PRECISION**

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

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

4.13.5 Operand **CHAM_EXCLU**

◇ `CHAM_EXCLU = (`
`| 'DEPL',`
`| 'QUICKLY',`
`| 'ACCE',`
`)`

Allows to exclude filing from one or more fields among 'DEPL', 'QUICKLY' and 'ACCE'.

This exclusion is ignored for the last moment of calculation: the three fields are necessary for one CONTINUATION.

4.14 Operand **TITLE**

◇ `TITLE = title`

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

5 Produced concept

`dyn` is a produced concept of type `dyna_trans` who will contain from 1 to 3 fields with the nodes for each filed moment.

These `cham_no` have as a reference symbol:

DEPL : displacement
QUICKLY : speed
ACCE : acceleration

6 Production run

The use of the diagrams of the centered differences and adaptive imposes certain restrictions of use:

- these two diagrams require the use of a matrix of diagonal mass. A test checks that the matrix of mass was created with the option 'MASS_MECA_DIAG' of `CALC_MATR_ELEM`. In addition, the matrix of mass must be stored in line of sky,
- there should not be other boundary conditions only blocked degrees of freedom. A test checks that there are no boundary conditions of the connections type between degrees of freedom. It is not either possible to impose nonworthless displacements via an assembled vector,
- for the diagram of the centered differences, one makes sure that the step of selected time checks the stability conditions:

$dt < 0,05 / f_{max}$ with $f_{max} = \max_{1 \leq i \leq nddl} \left(\frac{1}{2\pi} \sqrt{\frac{k_{ii}}{m_{ii}}} \right)$ and k_{ii} and m_{ii} diagonal terms of the matrices of stiffness and mass.

7 Bibliography

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