Operator **DYNA_VISCO**

1 Goal

This order allows to calculate the real or complex clean modes, like the harmonic answer (displacement, speed, acceleration) of one structure comprising of the viscoelastic materials whose properties depend on the frequency (what results in a matrix of rigidity dependent on the frequency).

The following actions are possible:

- obtaining the modes by iterative method; 3 types of modes to the choice: real modes, real beta-modes or complex modes, with taking into account of the frequency response of the mechanical properties of viscoelastic materials;
- if there is an excitation, calculation of the harmonic answer of the structure; is calculated by projection on the modal basis established at the preceding stage, then restitution on the physical basis.

For more theoretical details, to refer to the reference document [R5.05.10].

The order can produce a concept of the type `mode_meca, mode_meca_c, dyna_harmo`.

**Notice:**

- The order currently does not allow the calculation of the double modes;
- The structural analysis with modes of rigid body can not converge.
2 Syntax

visco [*] = DYNA_VISCO ( 

# Assignment of the model and the grid
   ◇ MODEL = model, [modele_sdaster]

# Assignment of the characteristics of the elements and the limiting conditions
   ◇ CARA_ELEM = caraelem, [cara_elem]

# Assignment of materials
   # elastic materials classical (constant properties)
      ◇ MATER_ELAS = _F ( 
         ◇ / MATER = chechmate [mater_sdaster]
         ◇ / E = E [R]
         ◇ / AMOR_HYST = amorhyst [R]
         ◇ / RHO = rho [R]
         ◇ / NAKED = naked [R]
         ◇ / GROUP_MA = gma [l_gr_maille]
      )

   # materials viscoelastic (properties dependent on the frequency)
      ◇ MATER_ELAS_VO = _F ( 
         ◇ / E = l_e [fonction_sdaster]
         ◇ / AMOR_HYST = l_amor [fonction_sdaster]
         ◇ / RHO = rho [R]
         ◇ / NAKED = naked [R]
         ◇ / GROUP_MA = gma [grma]
      )

# Choice of calculation to be carried out
   ◇ TYPE_RESU = / 'HARM' [DEFECT]
      / 'MODE'
   ◇ TYPE_MODE = / 'REAL' [DEFECT]
      / 'BETA'
      / 'COMPLEX' (only if TYPE_RESU=' MODE')

# Choice of the frequencies of calculation:
   ◇ /FREQ = l_f [l_R]
   / LIST_FREQ = lfreq [listr8]
   # Rq: if TYPE_RESU=' MODE', these keyword inform the frequential band of research of the clean modes and must thus comprise 2 values exactly
   # Rq: if TYPE_RESU=' HARM', these keyword inform the discrete frequencies of calculation of the harmonic answer; the maximum value of the list, multiplied by COEF_FREQ_MAX, is the upper limit of research of the clean modes.

# Parameter setting of convergence on the clean modes
   ◇ RESI_RELA = 1.E-3 [EPS] [DEFECT]
     / eps [R]

# If TYPE_RESU=' HARM' :
   ◇ COEF_FREQ_MAX = cfmmax [R]
# Assignment of the loading

♦ EXCIT = _F (  
    ♦ LOAD = load [l_char_meca]  
)

# Choice of (of) the field (S) of result to save

♦ NOM_CHAM = ‘DEPL’ [DEFECT]  
    / ‘QUICKLY’  
    / ‘ACCE’

# possible Storage of the calculated clean modes

♦ MODE_MECA = CO (”modes”) [TXM]

# Posting of the relative information to calculation

♦ INFORMATION = / 1 [DEFECT]  
    / 2  
);

# Standard of concept result

If TYPE_RESU = ‘HARM’ then [*] = dyna_harmo  
    if MODE_MECA present, the concept CO is of type mode_meca.

If TYPE_RESU = ‘MODE’ then [*] = mode_meca  
    if TYPE_MODE = ‘REAL’ or ‘BETA’  
    mode_meca_c if TYPE_MODE = ‘COMPLEX’.
3 Operands

3.1 Operands MODEL/CARA_ELEM

- MODEL = model,
- CARA_ELEM = caraelem,

These keywords make it possible to inform:
- the name of the model (model) whose elements are the object of mechanical calculation.
- the name of the characteristics of the structural elements (plates, beams, discrete,…) if they are used in the model.

3.2 Keyword factor MATER_ELAS

\[ \text{MATER_ELAS} = \_F \{
\begin{align*}
& / \text{MATER} = \text{checkmate} \\
& / \text{E} = \text{E} \\
& \text{AMOR_HYST} = \text{amorhyst} \\
& \text{RHO} = \text{rho} \\
& \text{NAKED} = \text{naked} \\
& \text{GROUP_MA} = \text{gma}
\end{align*}
\]

This keyword makes it possible to affect an elastic material without frequency response with the elements belonging to GROUP_MA.

The material can be defined before the macro-order thanks to the operator DEFI_MATERIAU [U4.43.01]; in this case, this material is recalled with the keyword MATER. The material can also be defined here by its properties: Young modulus E, density RHO, Poisson's ratio NAKED, and damping hysteretic AMOR_HYST.

This keyword factor can be repeated as many times as there are elastic materials without frequency response in the structure.

3.3 Keyword factor MATER_ELAS_FO

\[ \text{MATER_ELAS_FO} = \_F \{
\begin{align*}
& \text{E} = \text{l_e} \\
& \text{AMOR_HYST} = \text{l_amor} \\
& \text{RHO} = \text{rho} \\
& \text{NAKED} = \text{naked} \\
& \text{GROUP_MA} = \text{gma}
\end{align*}
\]

This keyword makes it possible to affect a viscoelastic material with frequency response with the elements belonging to GROUP_MA.

The mechanical properties of viscoelastic material are of two types:
- those which depend on the frequency: the Young modulus E and the damping ratio AMOR_HYST; they are indicated by functions indexed by the frequency, produced by DEFI_FONCTION/NOM_PARA='FREQ' [U4.31.02]);
- those which are constant: density RHO and the Poisson's ratio NAKED.

This keyword factor can be repeated as many times as there are materials viscoelastic with frequency response in the structure.
3.4 **Keyword TYPE_RESU**

◦ `TYPE_RESU = / 'HARM'` [DEFECT]
  
  ◦ `TYPE_RESU = / 'MODE'`

This keyword makes it possible to define the type of calculation to be carried out:
- LE choice ‘MODE’ allows to calculate the clean modes of the structure;
- calculation ‘HARM’, allows to obtain frequency response of the structure a given excitation; one can also recover the clean modes calculated thanks to the keyword `MODE_MECA`.

3.5 **Keywords FREQ/LIST_FREQ**

◦ `/ FREQ = l_f`
  
  ◦ `/ LIST_FREQ = lfreq`

In the case of a modal calculation of the structure (`TYPE_RESU=' MODE'`), this keyword makes it possible to define the frequential band of research of the modes. The list must then contain 2 values exactly (strictly increasing).

In the case of a harmonic calculation of the structure (`TYPE_RESU=' HARM'`), this keyword makes it possible to define the discrete frequencies for which the answer of the structure is calculated. The list must then contain at least 2 strictly increasing values.

3.6 **Keyword TYPE_MODE / RESI_RELA**

◦ `TYPE_MODE = / 'REAL'` [DEFECT]
  
  ◦ `/ 'BETA'`
  
  ◦ `/ 'COMPLEX'`

Several choices of calculation of the clean modes are possible: real modes, beta-modes (which are real modes improved giving a better precision of the results, cf [R5.05.09]), like complex modes. The calculation of the complex modes makes it possible to obtain modal depreciation. On the other hand this kind of mode cannot be used to carry out a harmonic calculation (`TYPE_RESU=' HARM'`).

Note:

- If one calculates complex modes, one can recover modal depreciation in a list python with this function: `liste_python=modal.LISTE_PARA () ['AMOR_REDUIT']` (that nécessite to use `PAR_LOT=' NON' in the order BEGINNING`).

◦ `RESI_RELA = / 1.E-3` [DEFECT]
  
  ◦ `/ eps`

The calculation of the clean modes with the iterative method has named convergence criteria `RESI_RELA`. A clean mode is retained in the modal base when the relative difference between the Eigen frequencies calculated between two successive iterations is lower than `RESI_RELA`.

3.7 **Keyword factor EXCIT**

◦ `EXCIT = _F (`
  
  ◦ `LOAD = load`

This keyword allows the assignment of loads (boundary conditions, forces of excitation,...) who were before defined by the operator `AFFE_CHAR_MECA` [U4.44.01].
Note:
Currently, for the external excitations, only the excitations of the type FORCE_NODALE are compatible with the order DYNA_VISCO.
For harmonic calculation, the base of the clean modes is enriched, a transparent way for the user, by the static modes associated with the excited nodes.

3.8 **Keyword NOM_CHAM** *(if TYPE_RESU='HARM')*

◊ NOM_CHAM = /'DEPL'/ [DEFECT]
◊ /'QUICKLY'/
◊ /'ACCE'/

This keyword makes it possible to define which fields will be saved in the concept result (displacement, speed or acceleration). It is possible to save several fields by giving a list, for example NOM_CHAM= ('DEPL', 'ACCE').

3.9 **Keyword MODE_MECA** *(if TYPE_RESU='HARM')*

◊ MODE_MECA = CO ('modes')

If this keyword is present, two concepts will be produced by the macro-order:
- the concept modes of type mode_meca
- the concept visco of type dyna_harmo

The concept modes can for example be classically printed with the order IMPR_RESU [U4.91.01].

3.10 **Keyword COEF_FREQ_MAX** *(if TYPE_RESU='HARM')*

◊ COEF_FREQ_MAX = cfmax [R]

During a harmonic calculation, the multiplying coefficient COEF_FREQ_MAX allows to obtain values of more precise frequency response, while multiplying by COEF_FREQ_MAX the value of the maximum frequency of calculation of the modal base of projection.
The minimal value of this parameter is 1.5.

3.11 **Keyword INFORMATION**

◊ INFORMATION = / 1 [DEFECT]
◊ / 2

Indicate the level of impression in the file MESSAGE.
4 Examples

4.1 Definition of the frequency response of the properties of viscoelastic materials

# frequencies for which the parameters of materials are given
list_f=DEFI_LISTE_REEL (VALE= (1,10,50,100,500,1000,1500,),);

# values (of the real part) of the Young modulus at the frequencies of list_f

# values of the factor of loss at the frequencies of list_f
list_eta=DEFI_LISTE_REEL (VALE= (1.1, 0.85, 0.7, 0.6, 0.4, 0.35, 0.34,),);

fonc_E=DEFI_FONCTION (NOM_PARA=' FREQ',
   VALE_PARA=liste_f,
   VALE_FONC=liste_E,
   INTERPOL= ('FLAX', 'FLAX',),
   PROL_DROITE=' LINEAIRE',
   PROL_GAUCHE=' CONSTANT',);

fonc_eta=DEFI_FONCTION (NOM_PARA=' FREQ',
   VALE_PARA=liste_f,
   VALE_FONC=liste_eta,
   INTERPOL= ('FLAX', 'FLAX',),
   PROL_DROITE=' LINEAIRE',
   PROL_GAUCHE=' CONSTANT',);

4.2 Calculation of the complex clean modes

modes=DYNA_VISCO (MODELE=modele,
   CARA_ELEM=cara_ele,
   # materials with constant properties:
   MATER_ELAS=_F (E=2.1e11,
      NU=0.3,
      RHO=7800.,
      AMOR_HYST=0.002,
      GROUP_MA=' SUPPORT'),)
# materials with properties dependent on the frequency:
MATER_ELAS_FO = _F (E=fonc_E,
    AMOR_HYST=fonc_eta,
    RHO=1200.,
    NU=0.45,
    GROUP_MA=' VISCO'),
TYPE_RESU=' MODE',
TYPE_MODE=' BETA',
# bandages frequential of research
FREQ= (1. , 1500.),
EXCIT=_F (CHARGE=condlim),
);

4.3 Calculation of the harmonic answer

# DEFINITION OF THE LOADING
excit=AFFE_CHAR_MECA (MODELE=modele,
    FORCE_NODALE=_F (GROUP_NO=' A',
        FZ=1.,)),);

# DEFINITION OF THE FREQUENCIES OF CALCULATION OF THE ANSWER
listfr=DEFI_LISTE_REEL (DEBUT=1.,
    INTERVALLE= (_F (JUSQU_A=500.,
        PAS=1.,)),));

# ANSWER HARMONIC
visco=DYNA_VISCO (MODELE=modele,
    CARA_ELEM=cara_ele,
    EXCIT=_F (CHARGE= (condlim, excit),),
    MATER_ELAS= (_F (E=2.1E11,
        NU=0.3,
        RHO=7800.,
        AMOR_HYST=0.002,
        GROUP_MA=' DESSOUS'),),
    _F (E=7.0E10,
        NU=0.3,
        RHO=2700.,
        AMOR_HYST=0.001,
        GROUP_MA=' DESSUS'),),);
MATER_ELAS_FO= ( _F (E=fonc_E,
               AMOR_HYST=fonc_eta,
               RHO=1200.,
               NU=0.45,
               GROUP_MA=' VOLUME'),)

TYPE_RESU=' HARM',
TYPE_MODE=' REEL',
LIST_FREQ=listfr,
# fields with saved
NOM_CHAM= ('DEPL', 'QUICKLY'),
# saves clean modes of the structure:
MODE_MECA=CO ('modes'),
);