SDNV107 – Plastic beam in dynamically condensed traction

Summary:

This test implements the dynamic resolution of several fields on the basis of Ritz by the operator DYNA_NON_LINE with calculation transitory reduced to the nonlinear fields and taken into account once and for all of linear fields already condensed dynamically by this base of Ritz containing the clean modes of each under-field as well as the static modes of connection between under-fields.

One presents to it like case of application a beam with plastic law of behavior subjected to a force of sinusoidal traction applied in his end. Nonlinear dynamic calculation applies only to the extreme third of the beam, the rest being condensed dynamically.

The maximum displacements obtained in the end are compared with those obtained by a direct dynamic calculation with DYNA_NON_LINE on the whole of the beam which constitutes the results of reference.
The one second alternative modeling is added for the same geometry: it puts in œuvre method of condensation dynamic by static macronutrients. This time, one condenses by only one static macronutrient the two fields of linear behavior and one also reduces the nonlinear field of calculation to the extreme third of the beam. One proceeds to it to the same comparison of the maximum displacements obtained in the end with the results of reference of direct dynamic calculation on the whole of the beam.
The comparison is conclusive for 2 modelings.

The third introduced modeling is similar to the first. One permutes simply the roles of the first and the third sub-model compared to modeling A in order to introduce the loading on a field condensed to test the keyword EXCIT_GENE. In addition, one carries out a resumption of calculation by calculating a second evolution on scale model where one uses as initial conditions displacements, speeds and accelerations generalized resulting from projection on the basis of Ritz of the fields of the first evolution at the moment of resumption of the second calculation.

1 Problem of reference

1.1 Geometry

One considers a right beam length $30\,m$, of square section $1\mathrm{m}\times 1\mathrm{m}$, split in 3 sub-models of $10\,m$ of length each one.

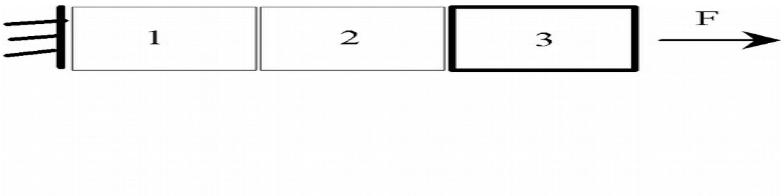

Figure 1.1-1: Geometry of the whole of the beam in traction.

1.2 Properties of materials

One considers a material of which characteristics of linear behavior (Young modulus E , Poisson's ratio ν , density ρ) are summarized in the table hereafter:

Material	E [Pa]	ρ [kg/m^3]	ν
-	4.0 E11	1000	0.

Table 1.2-1: Linear mechanical characteristics of material.

These linear characteristics are assigned to the first two sub-models. The third sub-model also has these characteristics as well as characteristics of linear isotropic plastic behavior with a plastic module of $4.0\,E10\;Pa$ beyond of a limit of constraint of $80\,MPa$.

1.3 Boundary conditions and loadings mechanical

The beam is embedded at the left of sub-model 1 and free end at the right end of sub-model 3. For the calculation of the clean modes of each substructure as well as static modes of the connections between substructures 1 and 2 on the one hand, 2 and 3d' another share, one also embeds on the level of these connections.

The excitation of the structure is carried out while applying at the right end $P3$ sub-model 3 a force of sinusoidal traction in time in the horizontal direction X of frequency $50\,Hz$ and of module $100\,MNewtons$.

2 Reference solution

2.1 Method of calculating used for the reference solution

The reference solution is obtained by a direct dynamic calculation with DYNA_NON_LINE on the whole of the sub-models.

2.2 Results of reference

One retains like results of reference the maximum displacements obtained in right end of sub-model 3 by a direct dynamic calculation with DYNA_NON_LINE on the whole of the sub-models.

3 Modeling A

3.1 Characteristics of modeling

Each sub-model is with a grid by solid elements HEXA8 with 8×8 elements to represent the square section of $1\text{m}\times1\text{m}$ and 10 elements according to the length of $10\,m$.

3.2 Characteristics of the grid

Each of the 3 sub-models thus consists of 640 meshs HEXA8 including 891 nodes is 2773 degrees of freedom. The unit understands 1920 meshs, 2511 nodes and 7533 degrees of freedom.

3.3 Parameters of calculation

Dynamic calculation is carried out on an interval of $0.014\,s$ by step of time of $8.333\,E-6\,s$. Filing is carried out for each step of time of $5.\,E-4\,s$.

4 Results of modeling A

4.1 Values tested

Identification	Reference	Tolerance
DEPL P3 - DX ($0.005\,s$)	$1.12284\,E-2\,m$	0.1%
DEPL P3 - DX ($0.014\,s$)	$-1.00389\,E-2\,m$	0.1%
QUICKLY P3 - DX ($0.003\,s$)	$4.13173\,m/s$	0.1%
DEPL P3 - DX ($0.005\,s$)	$1.13478\,E-2\,m$	1.1%
DEPL P3 - DX ($0.014\,s$)	$-0.99345\,E-2\,m$	1.1%

5 Modeling B

5.1 Characteristics of modeling

One condenses in the same static macronutrient the first both sub-model with a grid each one by solid elements HEXA8 with 8×8 elements to represent the square section of $1\mathrm{m}\times1\mathrm{m}$ and 10 elements according to the length of $10\,m$. The third sub-model to which relates the nonlinear dynamic analysis has the same discretization exactly.

5.2 Characteristics of the grid

Each of the 3 sub-models thus consists of 640 meshs HEXA8 including 891 nodes is 2773 degrees of freedom. The unit understands 1920 meshs, 2511 nodes and 7533 degrees of freedom.

5.3 Parameters of calculation

Dynamic calculation is carried out on an interval of $0.014\,s$ by step of time of $2.5\,E-4\,s$. Filing is carried out for each step of time of $5.\,E-4\,s$.

6 Results of modeling B

6.1 Values tested

Identification	Reference	Tolerance
DEPL P3 - DX ($0.005\,s$)	$1.13490\,E-2\,m$	0.1%
DEPL P3 - DX ($0.014\,s$)	$-0.99339\,E-2\,m$	0.1%
QUICKLY P3 - DX ($0.0035\,s$)	$3.99430\,m/s$	0.1%
DEPL P2 - DX ($0.005\,s$)	$6.97145\,E-3\,m$	0.1%
DEPL P3 - DX ($0.005\,s$)	$1.13478\,E-2\,m$	0.2%
DEPL P3 - DX ($0.014\,s$)	$-0.99345\,E-2\,m$	0.2%

7 Modeling C

7.1 Characteristics of modeling

Each sub-model is with a grid by solid elements HEXA8 with 8×8 elements to represent the square section of $1\mathrm{m}\times1\mathrm{m}$ and 10 elements according to the length of $10\,m$.

Characteristics of linear isotropic plastic behavior with a plastic module of $4.0\,E10\;Pa$ beyond of a limit of constraint of $80\,MPa$ are applied this time to the first sub-model instead of third sub-model compared to modeling A. This allows to test the keyword `EXCIT_GENE` of `DYNA_NON_LINE`. One also carries out a resumption of calculation by calculating a second evolution on scale model where one uses as initial conditions displacements, speeds and accelerations generalized resulting from projection on the basis of Ritz of the fields of the first evolution at the moment of resumption of the second calculation.

7.2 Characteristics of the grid

Each of the 3 sub-models thus consists of 640 meshs HEXA8 including 891 nodes is 2773 degrees of freedom. The unit understands 1920 meshs, 2511 nodes and 7533 degrees of freedom.

7.3 Parameters of calculation

Dynamic calculation is carried out on an interval of $0.016\,s$ by step of time of $8.333\,E-6\,s$. Filing is carried out for each step of time of $5.\,E-4\,s$. One thus carries out a resumption of calculation by calculating a second evolution with initial conditions resulting from the fields of the first evolution at the moment of recovery from $4.\,E-3\,s$.

8 Results of modeling C

8.1 Values tested

Identification	Reference	Tolerance
DEPL P3 - DX ($0.0055\,s$)	$1.17404\,E-2\,m$	0.1%
DEPL P3 - DX ($0.016\,s$)	$-1.13248\,E-2\,m$	0.1%
QUICKLY P3 - DX ($0.003\,s$)	$3.95547\,m/s$	0.1%
DEPL P3 - DX ($0.0055\,s$)	$1.17615\,E-2\,m$	0.2%

9 Summary of the results

For modeling A, the results of reference of the first two maximum got by direct answer (red curve) are well found by calculation on the basis of modal Ritz without static correction (green curve) with approximately 1.1% for a time-saver of calculation of report approximately 4. The addition of a mode of static correction due to the request in traction brings back this variation to less than 0.3%.

For modeling B, one finds rather exactly the results of reference.
Modeling C gives results similar to those of modeling A.