# SDNV107 – Plastic beam in dynamically condensed tension

**Summarized:**

This test by the operator implements the resolution dynamic of several fields on the basis of Ritz DYNA_NON_LINE with transient computation 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 eigen modes of each subdomain as well as the static modes of connection between subdomains.

One presents to it like case of application a beam with plastic constitutive law subjected to a sinusoidal tensile force applied in his end. The computation dynamic nonlinear 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 computation with DYNA_NON_LINE on the group of the beam which constitute the results of reference.
One second alternative modelization is added for the same geometry: it implements the method of condensation dynamic by static macro-elements. This time, one condenses by only one static macro-element the two fields of linear behavior and one also reduces the nonlinear field of computation 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 computation on the group of the beam.
The comparison is conclusive for the 2 modelizations.

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

# 1 Problem of reference

## 1.1 Geometry

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

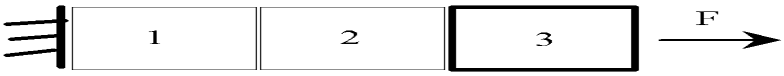


**Figure 1.1-1: Geometry of the group of the beam in tension.**

## 1.2 Properties of the materials

One considers a material whose characteristics of linear behavior (Young modulus $E$, Poisson's ratio $\nu$, density $\rho$) are summarized in the table hereafter:

| Material | $E$ [ $Pa$ ] | $\rho$ [ $kg/m^3$ ] | $\nu$ |
|---|---|---|---|
| - | 4.0 E11 | 1000 | 0. |

**Table 1.2-1: Linear mechanical characteristics of the 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 modulus of $4.0\,E10\ Pa$ beyond of a limit of stress of $80\,MPa$.

## 1.3 Mechanical boundary conditions and loadings

the beam is embedded at the left of sub-model 1 and free end at the right end of sub-model 3. For the computation of the eigen modes of each substructure as well as static modes of 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 structure is carried out by applying at the right end $P3$ of sub-model 3 a sinusoidal tensile force in time in the horizontal direction $X$ of frequency $50\,Hz$ and modulus $100\,MNewtons$.

# 2 Reference solution

## 2.1 Method of calculating used for the reference solution

the reference solution is obtained by a direct dynamic computation with DYNA_NON_LINE on all 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 computation with DYNA_NON_LINE on all the sub-models.

# 3 Modelization A

## 3.1 Characteristic of the modelization

Each sub-model is with a grid by solid elements HEXA8 with $8\times8$ elements to represent the square section of $1\mathrm{m}\times1\mathrm{m}$ and 10 elements according to the length of $10\,m$ .

## 3.2 Characteristics of the mesh

Each of the 3 sub-models thus makes up of 640 meshes HEXA8 including 891 nodes is 2773 degrees of freedom. The group understands 1920 meshes, 2511 nodes and 7533 degrees of freedom.

## 3.3 Parameters of computation

The computation dynamic is carried out on an interval from $0.014\,s$ time step of $8.333\,E-6\,s$ . The archivage is carried out for each time step $5.\,E-4\,s$ .

# 4 Results of the modelization 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% |
| VITE 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 Modelization B

## 5.1 Characteristic of the modelization

One condenses in the same static macro-element the first both sub-model with a grid each one by solid elements HEXA8 with $8\times8$ 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 mesh

Each of the 3 sub-models thus makes up of 640 meshes HEXA8 including 891 nodes is 2773 degrees of freedom. The group understands 1920 meshes, 2511 nodes and 7533 degrees of freedom.

## 5.3 Parameters of computation

The computation dynamic is carried out on an interval from $0.014\,s$ time step of $2.5\,E-4\,s$. The archivage is carried out for each time step $5.\,E-4\,s$.

# 6 Results of the modelization 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% |
| VITE 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 Modelization C

## 7.1 Characteristic of the modelization

Each sub-model is with a grid by solid elements HEXA8 with $8\times8$ elements to represent the square section of $1\mathrm{m}\times1\mathrm{m}$ and 10 elements according to the length of $10\,m$ .

The characteristics of linear isotropic plastic behavior with a plastic modulus of $4.0\,E10\,Pa$ beyond of a limit of stress of $80\,MPa$ are applied this time to the first sub-model instead of third sub-model compared to the modelization A. This makes it possible to test key word `EXCIT_GENE` of `DYNA_NON_LINE`. One also carries out a resumption of computation by calculating a second evolution on scale model where one uses as initial conditions displacements, velocities and accelerations generalized resulting from projection on the basis of Ritz of the fields of the first evolution to moment of recovery of the second computation.

## 7.2 Characteristics of the mesh

Each of the 3 sub-models thus makes up of 640 meshes HEXA8 including 891 nodes is 2773 degrees of freedom. The group understands 1920 meshes, 2511 nodes and 7533 degrees of freedom.

## 7.3 Parameters of computation

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

# 8 Results of the modelization 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% |
| `VITE 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 the modelization A, the results of reference of the first two maximum got by direct response (red curve) are well found by computation on the basis of modal base Ritz without static correction (green curve) with approximately 1.1% for a saving of time of computation of ratio approximately 4. The addition of a mode of static correction due to the request in tension brings back this variation to less than 0.3%.

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