# SDNL104 - transitory Under-structuring nonlinear: shock of a beam on 1 support

**Summary:**

The scope of application of this test relates to the dynamics of the structures, and more particularly the calculation of transitory answer nonlinear per dynamic under-structuring.

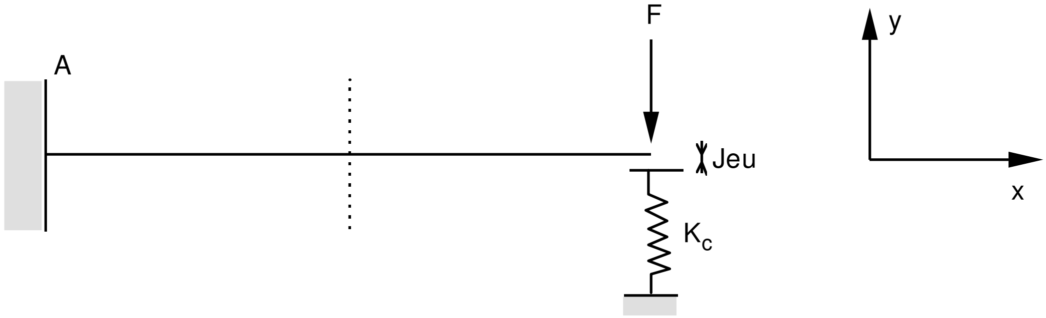
It is a question of calculating the nonlinear transitory answer of a beam in inflection with shock on a support elastic and subjected to a constant force as from the initial moment. The beam is modelled by elements of the type POU_D_E (model beam of Euler).

The results of reference result from a direct transitory calculation on the model not substructure, by using the operator DYNA_NON_LINE. This test thus makes it possible to validate the computational tools of response transitory by under - structuring, in the case of the taking into account of non-linearities of type shock on a fixed obstacle.

One also checks the interest of the static modes to enrich the base by projection and the orthogonalisation of the base.

# 1 Problem of reference

## 1.1 Geometry




The length of the beam is worth: $L=1\,m$

The section of the beam is full circular of ray: $R=0.1\,m$

The game between the beam and the elastic support is worth: $J=1\,10^{-4}\,m$

## 1.2 Material properties

$E=1.10^{10}\,Pa$

$\nu=0.3$

$\rho=1.10^{6}\,kg/m^{3}$

The stiffness within the competence of contact is worth: $K_c=1.10^{8}\,N/m$

## 1.3 Boundary conditions and loadings

On all the structure: $DX=DZ=DRY=DRX=0$ .

At the point $A$ : $DY=DRZ=0$ .

At the loose lead of the beam: as from the moment $t=0\,s$ , $Fy=-1000.\,N$

## 1.4 Initial conditions

Structure initially at rest.

# 2 Reference solution

## 2.1 Method of calculating used for the reference solution

The reference solution is given by a direct transitory calculation using the operator DYNA_NON_LINE (modeling A).

## 2.2 Results of reference

Value displacements, speed of the loose lead of the beam according to the direction $Y$ at the moment when their values are maximum, i.e. with $t=0.1315\,s$ for displacement and with $t=0.1566\,s$ for speed.

| | Displacement ( $m$ ) | Speed ( $m.s^{-1}$ ) |
|---|---|---|
| Diagram of Newmark | -1.853E-06 | -0.00463 |

## 2.3 Uncertainty on the solution

Digital solution.

# 3 Modeling A

## 3.1 Characteristics of modeling

The beam is with a grid in segments to which are affected of the elements of the type POU_D_E.

## 3.2 Characteristics of the grid

Many nodes: 11

Many meshs and types: 10 SEG2

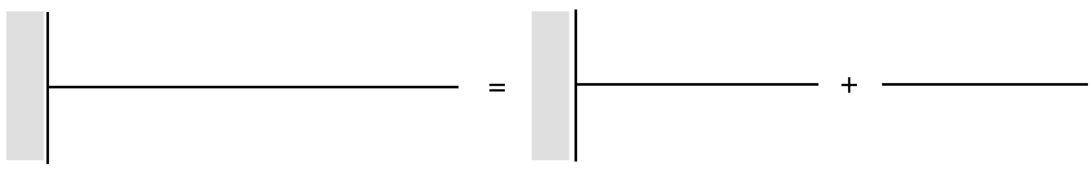
## 3.3 Actual values: references for modeling B

| Identification | *Aster* |
|---|---|
| **Diagram of Newmark** | |
| Displacement ( $m$ ) | -1.853E-06 |
| Speed ( $m.s^{-1}$ ) | -0.00463 |

# 4 Modeling B

## 4.1 Characteristics of modeling

The beam is cut out in 2 parts of equal size. Each substructure considered is with a grid in segments to which are affected of the elements of the type POU_D_E.



The structure is studied using the method of under-structuring with interfaces of the type "Craig - Bampton" (blocked interfaces).

The base of the first 5 clean modes of the complete structure is calculated by under - structuring. Then, the transitory problem, project on this basis, are solved by the transitory operator of calculation by modal recombination.

## 4.2 Characteristics of the grid

Many nodes: 6

Many meshs and types: 5 SEG2

## 4.3 Sizes tested and results

| Identification | Reference | *Aster* | % difference |
|---|---|---|---|
| **Diagram of integration of Euler** | | | |
| Displacement ( $m$ ) | -1.85356E-06 | -1.71889E-06 | 7.265% |
| Speed ( $m.s^{-1}$ ) | -4.63289E-3 | -4.486745E-3 | 3.154% |
| **Diagram of Devogelaere** | | | |
| Displacement ( $m$ ) | -1.85356E-06 | -1.71881E-06 | 7.269% |
| Speed ( $m.s^{-1}$ ) | -4.63289E-3 | -4.486672E-3 | 3.156% |
| **Diagram with step of adaptive time of order 2** | | | |
| Displacement ( $m$ ) | -1.85356E-06 | -1.71880E-06 | 7.270% |
| Speed ( $m.s^{-1}$ ) | -4.63289E-3 | -4.486748E-3 | 3.154% |

# 5 Modeling C

## 5.1 Characteristics of modeling

The beam is with a grid with elements of the type POU_D_E.

The transitory problem is solved in a direct way on various basic types of projection.

With the problem is dealt for four types of projection:

- on a basis made up of the first 5 normal modes;
- on a basis made up of the first 5 normal modes enriched by a static mode;
- on a basis made up of the first 5 normal modes enriched by a static mode and orthogonalisation by the base compared to the matrix by stiffness using the operand ORTHO=' OUI' of DEFI_BASE_MODALE ;
- on a basis made up of the first 5 normal modes enriched by a static mode and orthogonalisation by the base compared to the matrix by stiffness using the operand ORTHO_BASE of DEFI_BASE_MODALE .

## 5.2 Characteristics of the grid

Many nodes: 11

Many meshs and types: 10 SEG2

## 5.3 Actual values:

| Identification | Reference | *Aster* | % difference |
|---|---|---|---|
| **Base without static mode** | | | |
| Displacement ( $m$ ) | -1.85356E-06 | -1.7223385E-06 | 7.07977% |
| Speed ( $m.s^{-1}$ ) | -4.63289E-03 | -4.48406E-03 | 3.212% |
| **Base with static mode** | | | |
| Displacement ( $m$ ) | -1.85356E-06 | -1.88612E-06 | 1.7566% |
| Speed ( $m.s^{-1}$ ) | -4.63289E-03 | -4.65969E-03 | 0.578% |
| **Base with static mode + ORTHO=' OUI'** | | | |
| Displacement ( $m$ ) | -1.85356E-06 | -1.88612E-06 | 1.7566% |
| Speed ( $m.s^{-1}$ ) | -4.63289E-03 | -4.65969E-03 | 0.578% |
| **Base with static mode + ORTHO_BASE** | | | |
| Displacement ( $m$ ) | -1.85356E-06 | -1.88612E-06 | 1.7566% |
| Speed ( $m.s^{-1}$ ) | -4.63289E-03 | -4.65969E-03 | 0.578% |

# 6 Summary of the results

For modeling B, the precision on displacements of the loose lead of the beam at the moment $t=0.1315\,s$ is correct (relative error $<10\%$ ). This test thus validates the operators of non-linear transitory calculation by dynamic under-structuring.
Modeling C shows the interest of the enrichment of the base using the static modes.
The results are identical if the enriched modal base is orthogonalisé or not.