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.

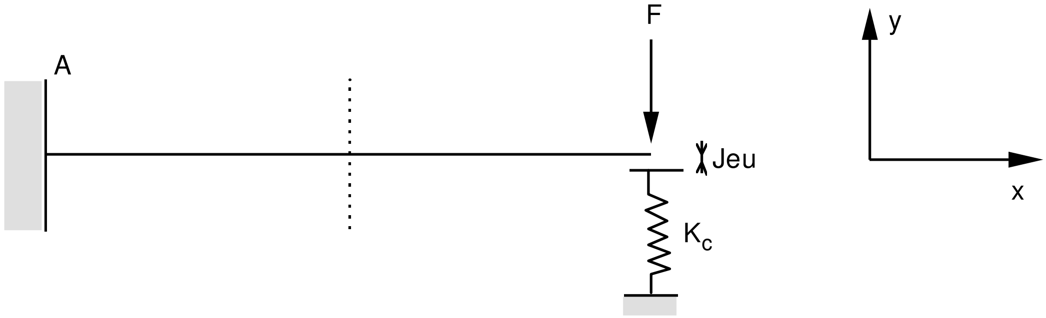
It is a question of calculating the nonlinear transitory answer of a beam in inflection with shock on a support elastic and subjected to a constant force as from the initial moment. The beam is modelled by elements of the type POU_D_E (model beam of Euler).

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

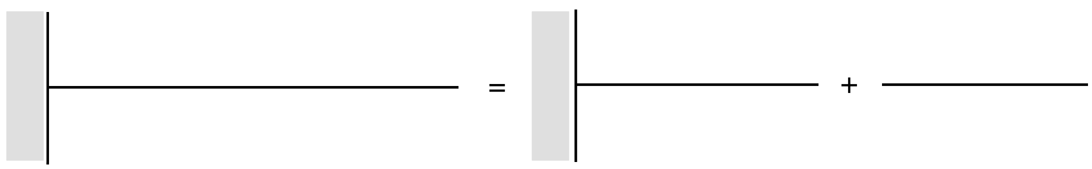
3.3 Actual values: references for modeling B

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.