SDNL105 - Nonlinear transitory substructuring: shock of 3 beams between them

Summarized:

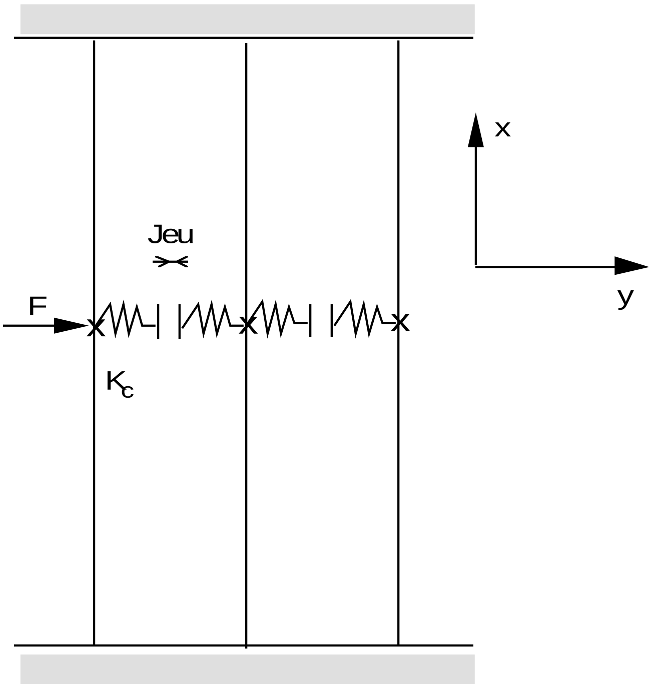
The scope of application of this test relates to the dynamics of structures, and more particularly the nonlinear computation of transient response per dynamic substructuring.

It is a question of calculating the nonlinear transient response of 3 beams in bending with shocks with the center of the beams. The beams are modelled by elements of the type POU_D_E (Eulerian models).

The results of reference result from a direct transient computation by modal recombination. This test thus makes it possible to validate the computational tools of transient response by under - structuring, in the case of the taking into account of non-linearities of type shock between mobile structures.

1 Problem of reference

1.1 Geometry



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

The beams are of circular section:

- of radius: $R=0.1\,m$
- of thickness: $ep=0.01\,m$

Clearance between the beams is worth: $Jeu=1\,10^{-3}\,m$

1.2 Material properties

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

$\nu=0.3$

$\rho=1.10^{8}\,kg/m^{3}$

the stiffness of the come out from contact is worth: $K_c=1.10^{8}\,N/m$

1.3 Boundary conditions and loadings

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

With the ends superior and inferior of the beams: $DY=DRZ=0$.

In the middle of the beam of left: from time $t=0\,s$, $Fy=-1.10^{6}\,N$

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 transient computation by modal superposition (modelization A).

2.2 Results of reference

Value of displacements and velocity of the nodes of the 3 beams according to the direction Y and at time $t=1\,s$.

	Displacement (m)	Velocity ($m.s^{-1}$)
Diagram of integration of Eulerian		
Beam of left	1.64 10-2	2.54 10-2
Beam medium	1.12 10-2	4.49 10-2
Beam of right	5.90 10-3	1.05 10-1
Diagram of integration of Devogelaere		
Beam of left	1.64 10-2	2.54 10-2
Beam medium	1.12 10-2	4.41 10-2
Beam of right	5.89 10-3	1.05 10-1
Diagram of integration to time step adaptive of order 2		
Beam of left	1.64 10-2	2.55 10-2
Beam medium	1.12 10-2	4.41 10-2
Beam of right	5.91 10-3	1.05 10-1

2.3 Uncertainty on the solution

numerical Solution.

3 Modelization A

3.1 Characteristic of the modelization

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

With the transitory problem dealt, project on the basis of eigen mode the first 15 of structure, is solved directly by the operator transient computation by modal recombination.

3.2 Characteristics of the mesh

Many nodes: 41

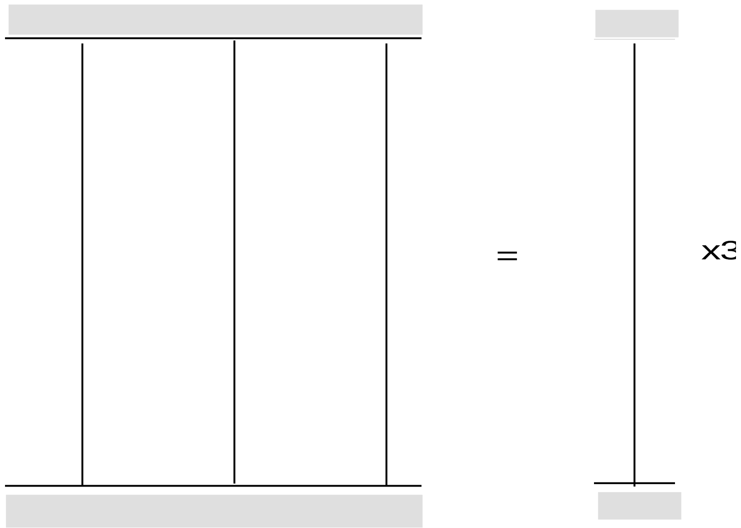
Number of meshes and types: 42 `SEG2`

3.3 Actual values: reference for modelization B

Identification	***Aster***
Diagram of integration of Eulerian	
Beam of left: Displacement (m)	1.64 10-2
Velocity ($m.s^{-1}$)	2.54 10-2
Beam of medium: Displacement (m)	1.12 10-2
Velocity ($m.s^{-1}$)	4.43 10-2
Beam of right: Displacement (m)	5.90 10-3
Velocity ($m.s^{-1}$)	1.05 10-1
Diagram of integration of Devogelaere	
Beam of left: Displacement (m)	1.64 10-2
Velocity ($m.s^{-1}$)	2.54 10-2
Beam of medium: Displacement (m)	1.12 10-2
Velocity ($m.s^{-1}$)	4.41 10-2
Beam of right: Displacement (m)	5.89 10-3
Velocity ($m.s^{-1}$)	1.05 10-1
Diagram of integration to time step adaptive of order 2	
Beam of left: Displacement (m)	1.64 10-2
Velocity ($m.s^{-1}$)	2.55 10-2
Beam of medium: Displacement (m)	1.12 10-2
Velocity ($m.s^{-1}$)	4.41 10-2
Beam of right: Displacement (m)	5.91 10-3
Velocity ($m.s^{-1}$)	1.05 10-1

4 Modelization B

4.1 Characteristic of the modelization



the dynamic substructuring makes it possible to calculate the vibratory behavior of the 3 beams starting from the dynamic characteristics of only one beam. This one 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 substructuring with interfaces of the type "Craig - Bampton" (blocked interfaces).

The base of the first 15 eigen modes of complete structure is calculated by substructuring. Then the transitory problem, project on this basis, is solved by the operator transient computation by modal recombination.

4.2 Characteristics of the mesh

Many nodes: 15

Number of meshes and types: 14 SEG2

4.3 Quantities tested and results

Identification	Reference	*Aster*	% difference
Diagram in integration of Eulerian			
Beam of left: Displacement (m)	1.64 10-2	1.64 10-2	
Velocity ($m.s^{-1}$)	2.54 10-2	2.54 10-2	
Beam of medium: Displacement (m)	1.12 10-2	1.12 10-2	< 0.01%
Velocity ($m.s^{-1}$)	4.43 10-2	4.43 10-2	
Beam of right: Displacement (m)	5.90 10-3	5.90 10-3	
Velocity ($m.s^{-1}$)	1.05 10-1	1.05 10-1	
Diagram of integration of Devogelaere			
Beam of left: Displacement (m)	1.64 10-2	1.64 10-2	
Velocity ($m.s^{-1}$)	2.54 10-2	2.54 10-2	
Beam of medium: Displacement (m)	1.12 10-2	1.12 10-2	< 0.01%
Velocity ($m.s^{-1}$)	4.41 10-2	4.41 10-2	
Beam of right: Displacement (m)	5.89 10-3	5.89 10-3	
Velocity ($m.s^{-1}$)	1.05 10-1	1.05 10-1	
Diagram of integration to time step adaptive of order 2			
Beam of left: Displacement (m)	1.64 10-2	1.64 10-2	
Velocity ($m.s^{-1}$)	2.55 10-2	2.55 10-2	
Beam of medium: Displacement (m)	1.12 10-2	1.12 10-2	< 0.01%
Velocity ($m.s^{-1}$)	4.41 10-2	4.41 10-2	
Beam of right: Displacement (m)	5.91 10-3	5.91 10-3	
Velocity ($m.s^{-1}$)	1.05 10-1	1.05 10-1	

5 Summary of the results

the accuracy on displacements and the velocities of the nodes mediums of the 3 beams at time $t=1\,s$ is excellent (relative error $<0.01\mathrm{s}$).

This test thus validates the operators of nonlinear transient computation by dynamic substructuring.