SDNL105 - transitory Under-structuring nonlinear: shock of 3 beams between them

Summary:

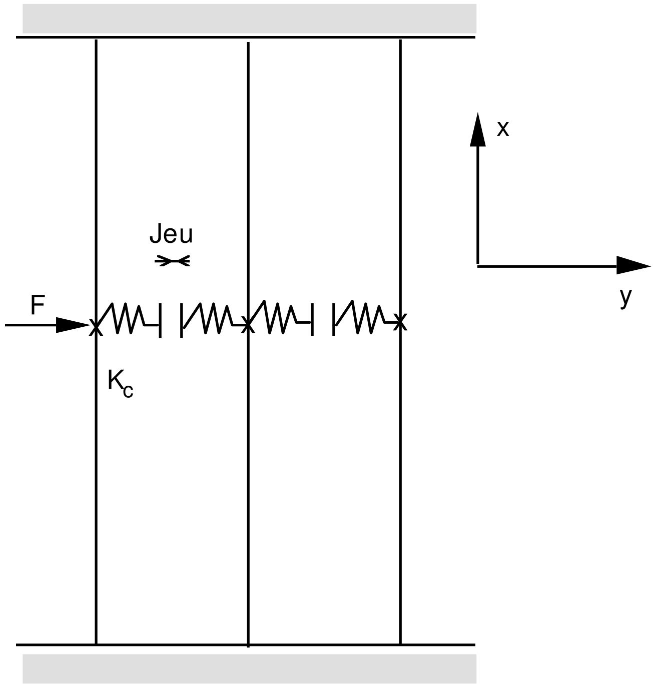
The scope of application of this test relates to the dynamics of the structures, and more particularly the calculation of transitory answer nonlinear per dynamic under-structuring.

It is a question of calculating the nonlinear transitory response of 3 beams in inflection with shocks to the center of the beams. The beams are modelled by elements of the type POU_D_E (model of Euler).

The results of reference result from a direct transitory calculation by modal recombination. 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 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 ray: $R=0.1\,m$
- of thickness: $ep=0.01\,m$

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

1.3 Boundary conditions and loadings

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

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

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

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 transitory calculation by modal superposition (modeling A).

2.2 Results of reference

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

	Displacement (m)	Speed ($m.s^{-1}$)
Diagram of integration of Euler		
Beam of left	$1.64\ 10^{-2}$	$2.54\ 10^{-2}$
Beam medium	$1.12\ 10^{-2}$	$4.49\ 10^{-2}$
Beam of right-hand side	$5.90\ 10^{-3}$	$1.05\ 10^{-1}$
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-hand side	$5.89\ 10^{-3}$	$1.05\ 10^{-1}$
Diagram of integration to step of adaptive time 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-hand side	$5.91\ 10^{-3}$	$1.05\ 10^{-1}$

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.

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

3.2 Characteristics of the grid

Many nodes: 41

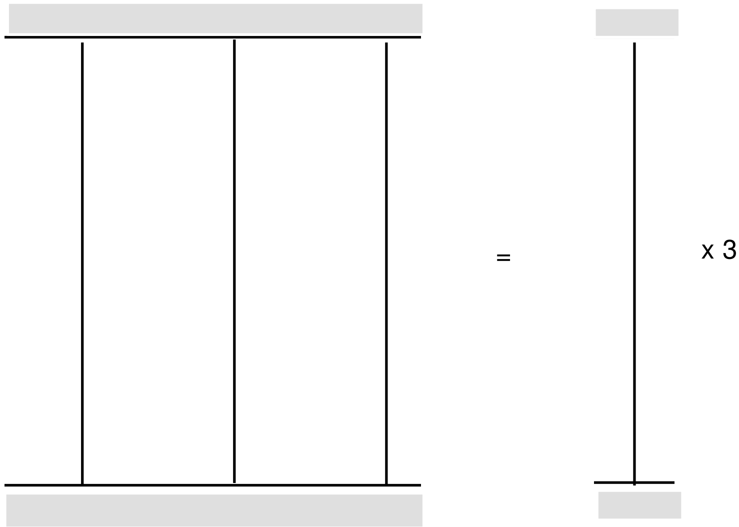
Many meshs and types: 42 SEG2

3.3 Actual values: reference for modeling B

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

4 Modeling B

4.1 Characteristics of modeling



The dynamic under-structuring 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 under-structuring with interfaces of the type "Craig - Bampton" (blocked interfaces).

The base of the first 15 clean modes of the complete structure is calculated by under-structuring. Then the transitory problem, project on this basis, is solved by the transitory operator of calculation by modal recombination.

4.2 Characteristics of the grid

Many nodes: 15

Many meshs and types: 14 SEG2

4.3 Sizes tested and results

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

5 Summary of the results

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

This test thus validates the operators of non-linear transitory calculation by dynamic under-structuring.