SDLL23 - Embed-free beam subjected to a seisme (spectral response)

Summarized

This one-way problem consists in carrying out a spectral seismic analysis of a embed-free beam, provided with two located masses, subjected to a three-dimensional excitation provided in the form of an oscillator spectrum in pseudo-acceleration.

Via this problem, one tests modal combinations DPC, SRSS, CQC and DSC of operator COMB_SISM_MODAL. Combination SRSS is tested with taking into account of the neglected modes.

In addition, one tests the operators of preprocessing MODE_ITER_SIMULT, NORM_MODE, MODE_STATIQUE, DEFI_FONCTION and DEFI_NAPPE.

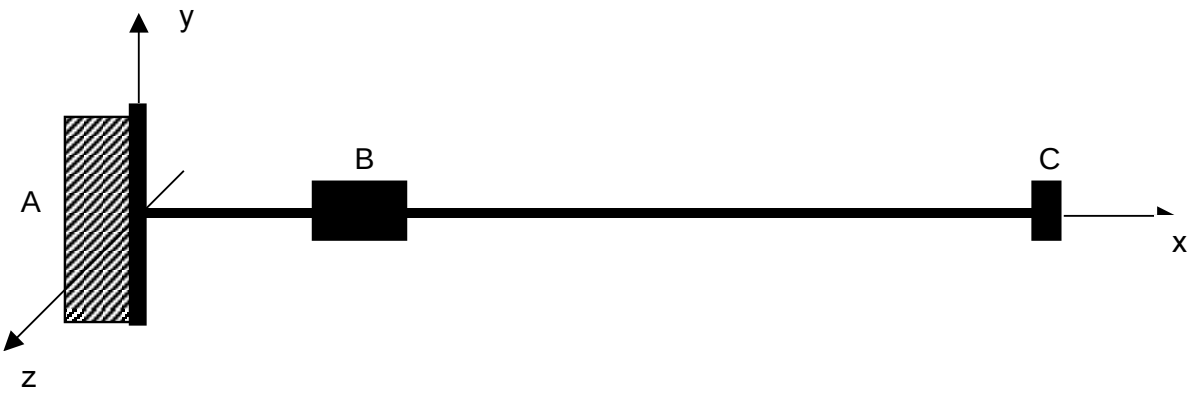
Concerning the modelization A, the got results, relative to beams of Eulerian, are in agreement with the results of other codes, for the cases without taking into account of the pseudo-mode. The differences with the results in reference if one takes into account the pseudo-mode explain by a design assumption different for the determination from this pseudo-mode.

The modelization B, out of beams of Eulerian, is relative to a mesh more refined than that of modelization A.

The modelization C comprises beams of Timoshenko and is relative to a mesh identical to that of the modelization B; the results show considerable variations with the modelization out of beams of Eulerian and are very sensitive to the shear coefficient.

1 Problem of reference

1.1 Geometry



Length of beam: $l=10\,m$
The mass B is at a distance from $0,5\,m$ point A.
Cross section of beam:
Area: $A=78.1\,10^{-4}\,m^2$
Main moments of inertia: $I_y=5696.10^{-8}\,m^4$
$I_z=2003.10^{-8}\,m^4$
$J_x=7699.10^{-8}\,m^4$

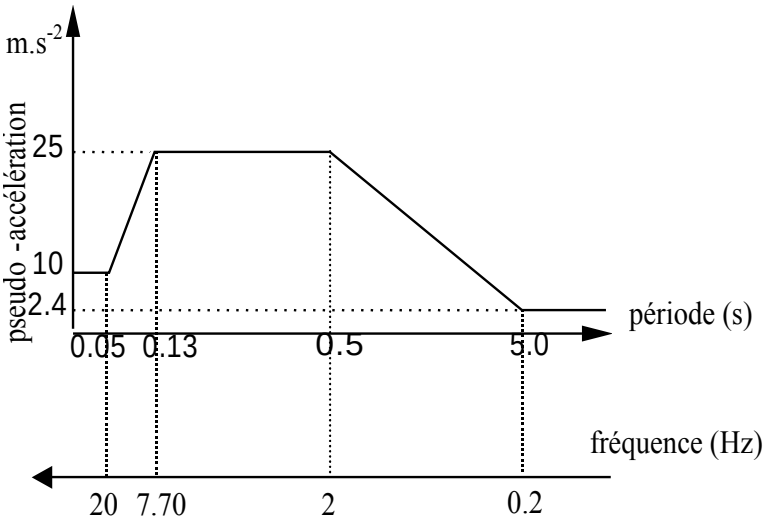
1.2 Material properties

Beam	modulus Young	$E=2.10^{11}\,Pa$	
	density	$\rho=0\,kg/m^3$	(mass of the beam null)
	Poisson's ratio	$\nu=0,3$	
Masses out of B		$m_B=50000\,kg$	
Mass in C		$m_C=5000\,kg$	

1.3 Boundary conditions and loadings

Not A clamped.

Oscillator spectrum in acceleration applied in A the three directions, of the same value for 3 depreciation $0,5\%$, 1% and $1,5\%$.



For computation, one uses a reduced damping of 1% , with an interpolation (LOG LOG) in frequency and (LIN LOG) damping.

2 Reference solution

2.1 Method of calculating used for the reference solution

Modelization a:
Guides VPCS (not appeared): comparison with codes STRUDL, LICE, SYSTUS, BEAVER, SAP IV [1].

For the comparison between the method CQC, comparison and Castem2000.

Modelization B and modelization C : non regression

2.2 Results of reference

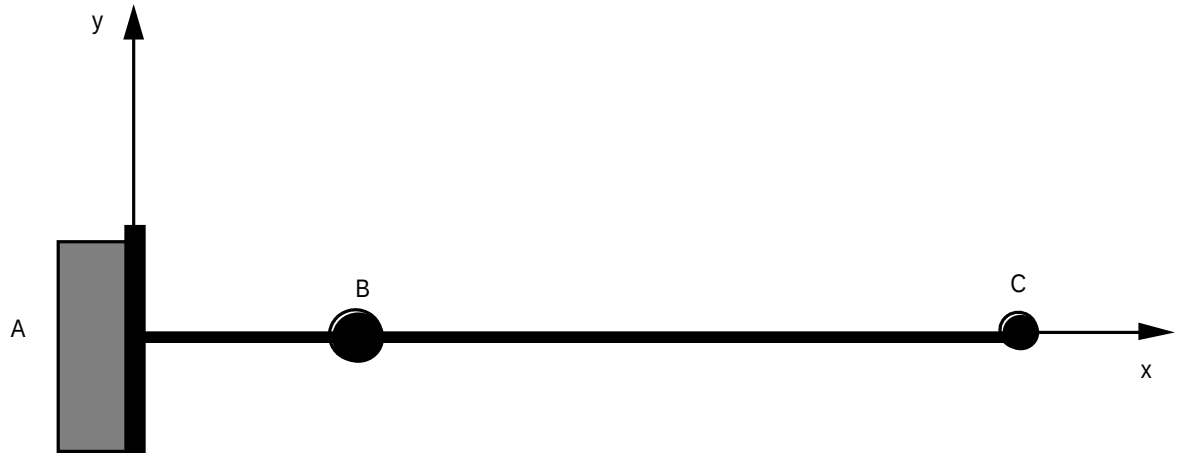
the first 6 eigenfrequencies and participation factors.
Displacements of the points B and C, nodal reaction at the point A (response on 3 modes for combinations DPC and SRSS, response on 6 modes for combinations DPC, CQC and DSC).

2.3 Bibliographical references

[1] J. PIRANDA, Laboratory of Mechanics Applied - University of Honest County Besancon (France). Card-index SFM – Validation of the Software packages of Structural analyzes – Dynamic analysis Group, June 1991. Guide VPCS 1991 not published.

3 Modelization A

3.1 Characteristic of the modelization



Poutre droite modélisée par 3 nœuds et 2 SEG2 de type POU_D_E
Masse modélisée par des éléments discrets M_T_N

This modelization containing 2 elements only is insufficiently refined to allow a good representation of the first 6 modes. It nevertheless is preserved in this benchmark for comparison with other codes like indicated in guide VPCS.

3.2 Characteristics of the mesh

Many nodes: 3

Number of meshes and types: 2 SEG2 (POU_D_E), 2 POI1 (DIS_T_N)

3.3 Parameters of modelization

Response on the first 3 modes without static correction (combination of modal responses DPC)
Response on the 6 modes (combination of modal responses DPC, CQC, DSC lasted: $5\,s$)
Response on the first 3 modes with static correction of the 3 neglected modes (combination of modal responses SRSS)

quadratic Combination of directional responses (QUAD).

3.4 Quantities tested and results

the values of reference are the averages of the results of the compared codes, thus of the values of non regression for computation with static correction.

Identification			Reference VPCS	non regression	Tolerance Reference	Tolerance
Eigenfrequencies						
1			0.24691	0.01		
2			0.41666	0.01		
3			7.4074	0.01		
4			12.5	0.01		
5			27.777	0.01		
6			41.666	0.01		
Direction	numéro_mode		Participation factor			
DY	1		73.3	0.01		
DZ	2		73.3	0.01		
DY	3.223		.	0.01		
DZ	4		-223.	0.01		
DX	5.130		.	0.01		
DX	6.195		.	0.01		
Response out of 3 modes (DPC)						
DEPL	B	DY	1.254E-02	0.02		
	B	DZ	2.8E-03	0.02		
	C	DY	1.269	0.02		
	C	DZ	7.574E-01	0.02		
REAC	A	DX	0.000	0.001		
	A	DY	1.231E+06	0.02		
	A	DZ	2.7E+04	0.02		
	A	DRY	2.56E+05	0.03		
	A	DRZ	5.91E+05	0.02		
Response out of 6 modes (DPC)						
DEPL	B	DX	1.32E-04	0.02		
	B	DY	1.255E-02	0.02		
	B	DZ	3.829E-03	0.02		
	C	DX	5.999E-04	0.02		
	C	DY	1.269	0.02		
	C	DZ	7.579E-01	0.02		
REAC	A	DX	4.12E+05	0.02		
	A	DY	1.227E+06	0.02		
	A	DZ	7.96E+05	0.02		
	A	DRY	4.49E+05	0.02		
	A	DRZ	5.90E+05	0.02		
Response (SRSS) on 3 modes with			static correction			
DEPL	B	DX	1.76E-04	1.6	4.401E-04	0.001
	B	DY	1.267E-02	0.02	0.012	0.001
	B	DZ	3.3E-03	0.5	4.949E-03	0.001
	C	DX	4.8E-04	1.6	1.200E-03	0.001
	C	DY	1.277	0.02	1.282	0.001
	C	DZ	0.762	0.02	0.767	0.001
REAC	A	DX	5.46E+05	1.6	1.375E+06	0.001
	A	DY	12.30E+05	0.02	1.241E+06	0.001
	A	DZ	4.90E+05	1.6	1.241E+06	0.001

	A	DRY	3.43E+05	0.85	6.337E+05	0.001
	A	DRZ	5.91E+05	0.02	5.969E+05	0.001
Response out of 6 modes (CQC)						
DEPL	B	DX	$1.337\ 10^{-4}$	0.02		
	B	DY	$1.247\ 10^{-2}$	0.02		
	B	DZ	$3.814\ 10^{-3}$	0.02		
	C	DX	6.012E-4	0.02		
	C	DY	1.282	0.02		
	C	DZ	0.767	0.02		
REAC	A	DX	4.18E+5	0.02		
	A	DY	12.40E+5	0.02		
	A	DZ	7.816E+5	0.02		
	A	DRY	4.481E+5	0.02		
	A	DRZ	5.969E+5	0.02		
Response out of 6 modes (DSC, lasted 5 S)						
DEPL	B	DX	$1.339\ 10^{-4}$	0.02		
	B	DY	$1.248\ 10^{-2}$	0.02		
	B	DZ	$3.816\ 10^{-3}$	0.02		
	C	DX	$6.009\ 10^{-4}$	0.02		
	C	DY	1.282	0.02		
	C	DZ	$7.673\ 10^{-1}$	0.02		
REAC	A	DX	$4.183\ 10^{5}$	0.02		
	A	DY	$1.240\ 10^{6}$	0.02		
	A	DZ	$7.816\ 10^{5}$	0.02		
	A	DRY	$4.483\ 10^{5}$	0.02		
	A	DRZ	$5.971\ 10^{5}$	0.02		

3.5 Remarks

Value of the spectrum (interpolation):

Mode	1	2	3	4	5	6
Spectrum	2.972	5.058	25.	15.74	10.	10.

Matrice de corrélation CQC :

$$\begin{pmatrix} 1 & 1.38E-3 & 5.05E-6 & 2.27E-6 & 6.85E-7 & 3.65E-7 \\ & 1 & 1.13E-5 & 5.05E-6 & 1.51E-6 & 8.04E-7 \\ & & 1 & 1.38E-3 & 1.64E-4 & 7.48E-5 \\ & & & 1 & 5.61E-4 & 2.04E-4 \\ & & & & 1 & 2.21E-3 \\ & & & & & 1 \end{pmatrix}$$

4 Modelization B

4.1 Characteristic of the modelization

Straight beam modelled by 22 nodes and 21 elements SEG2 of the type POU_DE.

4.2 Characteristics of the mesh

Many nodes: 22

Number of meshes and types: 21 SEG2 (POU_D_E), 2 POI1 (DIS_T_N)

4.3 Parameters of modelization

Response on the first 3 modes without static correction (combination of modal responses DPC)
Response on the 6 modes (combination of modal responses DPC, CQC, DSC lasted: 5 S)
Response on the first 3 modes with static correction of the 3 neglected modes (combination of modal responses SRSS)
quadratic Combination of directional responses (QUAD).

4.4 Quantities tested and results

the values of reference are values of non regression.

5 Modelization C

5.1 Characteristic of the modelization

Straight beam modelled by 22 nodes and 21 elements SEG2 of the type POU_D_TG.
This modelization was added to test the influence of the type of element beam considered. The shear coefficients AY and AZ ($AY = AZ = 6/5$) correspond to a right-angled section.

5.2 Characteristics of the mesh

Many nodes: 22

Number of meshes and types: 21 SEG2 (POU_D_TG), 2 POI1 (DIS_T_N)

5.3 Parameters of modelization

Response on the first 3 modes without static correction (combination of modal responses DPC)

Response on the 6 modes (combination of modal responses DPC, CQC, DSC lasted: $5s$)

Response on the first 3 modes with static correction of the 3 neglected modes (combination of modal responses SRSS).

Quadratic combination of directional responses (QUAD).

5.4 Quantities tested and results

the values of reference are values of non regression.

6 Summary of the results

Modelization a:
Case without taking into account of the pseudo-mode: perfect agreement of the Code_Aster *results* with the file of validation which indicates a tolerance of 2% on the values of reference.
Case with taking into account of the pseudo-mode: important differences with the file in validation, being able to go until 160% ; they are explained by a different design assumption (in the reference, the pseudo-mode is calculated from the value of the SRO corresponding to the asymptote of the spectrum, whereas, in *Code_Aster*, the pseudo-mode is calculated from the value of the SRO corresponding to the last frequency of modal base considered). It should be noted that the values obtained by *Code_Aster* are conservative compared to a computation with modal base not truncated before the cut-off frequency.

It should be noted that the modelizations B and C containing 21 elements cause a participation factor of mode 4 positive, whereas it is negative with modelization A.

the results of the modelization C (in particular nodal reactions) are very sensitive to the values of the shear coefficients.