

SDLL23 - Subjected embed-free beam with an earthquake (spectral response)

Summary

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 shape of a spectrum of oscillators in pseudo-acceleration.

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

In addition, the operators are tested `CALC_MODES`, `NORM_MODE`, `MODE_STATIQUE`, `DEFI_FONCTION` and `DEFI_NAPPE`.

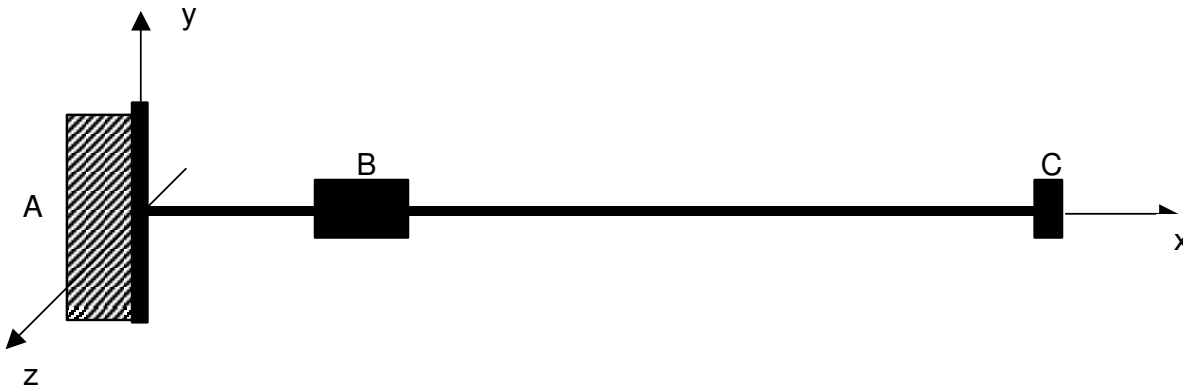
Concerning modeling A, the got results, relative to beams of Euler, are in agreement with the results of other codes, for the cases without taking into account of the pseudo-mode. The differences with the results in reference if one takes into account the pseudo-mode explain by a design assumption different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

Modeling B, in beams of Euler, is relative to a grid more refined than that of modeling A.

Modeling C comprises beams of Timoshenko and is relative to a grid identical to that of modeling B; the results show considerable variations with modeling in beams of Euler and are very sensitive to the coefficient of shearing.

1 Problem of reference

1.1 Geometry



Length of the beam: $l = 10 \text{ m}$

Mass B is at a distance from $0,5 \text{ m}$ point A .

Cross section of the beam:

Surface: $A = 78.1 \cdot 10^{-4} \text{ m}^2$

Moments of inertia: $I_y = 5696 \cdot 10^{-8} \text{ m}^4$

$I_z = 2003 \cdot 10^{-8} \text{ m}^4$

$J_x = 7699 \cdot 10^{-8} \text{ m}^4$

1.2 Material properties

Beam	Young modulus	$E = 2 \cdot 10^{11} \text{ Pa}$	(mass of the worthless beam)
	density	$\rho = 0 \text{ kg/m}^3$	
	Poisson's ratio	$\nu = 0,3$	

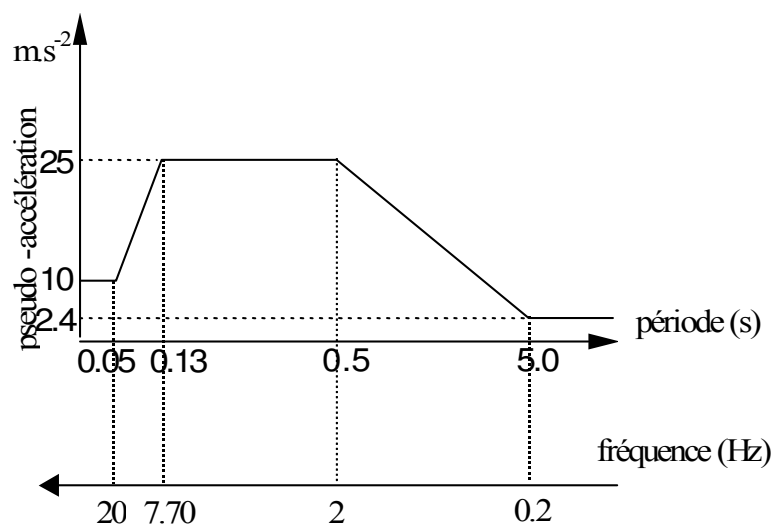
Mass in B $m_B = 50000 \text{ kg}$

Mass in C $m_C = 5000 \text{ kg}$

1.3 Boundary conditions and loadings

Not A embedded.

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



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

2 Reference solution

2.1 Method of calculating used for the reference solution

Modeling A :

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

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

Modeling B and modeling C : not regression

2.2 Results of reference

the first 6 Eigen frequencies and factors of participation.

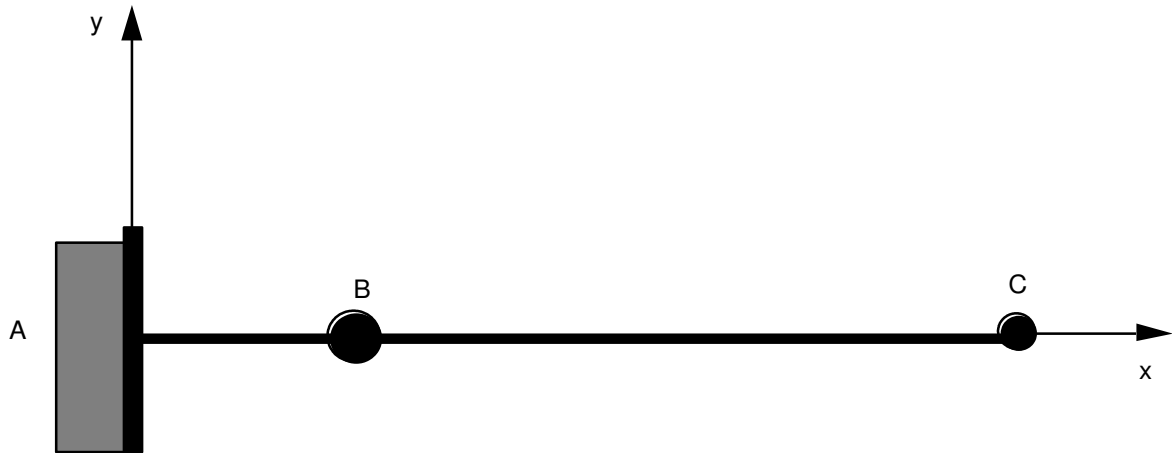
Displacements of the points B and C , nodal reaction at the point A (answer on 3 modes for combinations DPC and SRSS, answer on 6 modes for combinations DPC, CQC and DSC).

2.3 Bibliographical references

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

3 Modeling A

3.1 Characteristics of modeling



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

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

3.2 Characteristics of the grid

Many Nœuds: 3

Many meshes and types: 2 **SEG2** (**POU_D_E**), 2 **POI1** (**DIS_T_N**)

3.3 Parameters of modeling

Answer on the first 3 modes without static correction (combination of modal answers DPC)

Answer on the 6 modes (combination of modal answers DPC, CQC, lasted DSC: 5s)

Answer on the first 3 modes with static correction of the 3 neglected modes (combination of modal answers SRSS)

Quadratic combination of the directional answers (**QUAD**).

3.4 Sizes tested and results

The values of reference are the averages of the results of the compared codes, thus of the values of nonregression for calculation with static correction.

Identification	Reference VPCS	Tolerance	Reference not regression	Tolerance
Eigen frequencies				
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	Factor of participation		
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
Answer on 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
REACTIONARY DX	With		0,000	0,001
	With		1.231E+06	0.02
DY	With		2.7E+04	0.02
DZ	With		2.56E+05	0.03
DRY MARTINI	With		5.91E+05	0.02
DRZ				
Answer on 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
REACTIONARY DX	With		4.12E+05	0.02
	With		1.227E+06	0.02
DY	With		7.96E+05	0.02
DZ	With		4.49E+05	0.02
DRY MARTINI	With		5.90E+05	0.02
DRZ				
Answer (SRSS) on 3 modes static correction with				

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
REACTIONARY DX	With		5.46E+05	1.6	1.375E+06	0,001
	With		12.30E+05	0.02	1.241E+06	0,001
DY						
	With		4.90E+05	1.6	1.241E+06	0,001
DZ						
	With		3.43E+05	0.85	6.337E+05	0,001
DRY MARTINI						
	With		5.91E+05	0.02	5.969E+05	0,001
DRZ						
Answer on 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		
REACTIONARY DX	With		4.18E+5	0.02		
	With		12.40E+5	0.02		
DY						
	With		7.816E+5	0.02		
DZ						
	With		4.481E+5	0.02		
DRY MARTINI						
	With		5.969E+5	0.02		
DRZ						
Answer on 6 modes (DSC, duration 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		
REACTIONARY DX	With		4,183 10 ⁵	0.02		
	With		1,240 10 ⁶	0.02		
DY						
	With		7,816 10 ⁵	0.02		
DZ						
	With		4,483 10 ⁵	0.02		
DRY MARTINI						
	With		5,971 10 ⁵	0.02		
DRZ						

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.

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Matrice de corrélation CQC :

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

4 Modeling B

4.1 Characteristics of modeling

Right beam modelled by 22 Nœuds and 21 elements SEG2 of type POU_DE.

4.2 Characteristics of the grid

Many Nœuds: 22

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

4.3 Parameters of modeling

Answer on the first 3 modes without static correction (combination of modal answers DPC)

Answer on the 6 modes (combination of modal answers DPC, CQC, lasted DSC: 5 S)

Answer on the first 3 modes with static correction of the 3 neglected modes (combination of modal answers SRSS)

Quadratic combination of the directional answers (QUAD).

4.4 Sizes tested and results

The values of reference are values of nonregression.

5 Modeling C

5.1 Characteristics of modeling

Right beam modelled by 22 Nœuds and 21 elements SEG2 of type POU_D_TG.
This modeling was added to test the influence of the type of element beam considered. Coefficients of shearing AY and AZ ($AY = AZ = 6/5$) correspond to a right-angled section.

5.2 Characteristics of the grid

Many Nœuds: 22

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

5.3 Parameters of modeling

Answer on the first 3 modes without static correction (combination of modal answers DPC)

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

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

Quadratic combination of the directional answers (QUAD).

5.4 Sizes tested and results

The values of reference are values of nonregression.

6 Summary of the results

Modeling a:

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

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

The results of modeling C (in particular nodal reactions) are very sensitive to the values of the coefficients of shearing.