SDLL132 - Eigen modes of a frame out of multifibre beams

Summarized:

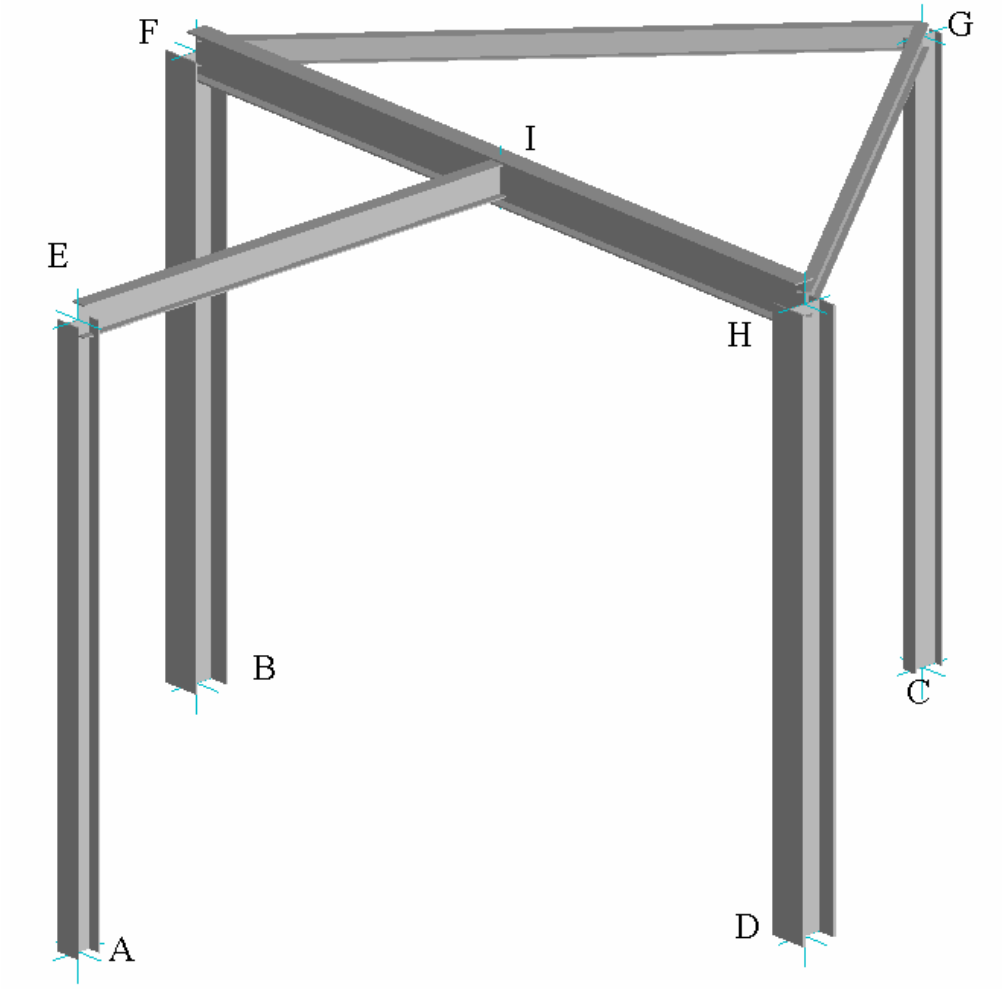
This test relates to the validation of option MASS_INER, as of the computation of the eigen modes of the frame when the model POU_D_TGM (multifibre beams) contain. The results of the reference solution are got by making the same study but with a model of beams based on POU_D_E.

This test makes it possible to validate, by making a modal analysis of structure:
linear finite elements of type POU_D_TGM.
results of the commands: POST_ELEM, NORM_MODE, EXTR_MODE.
results of MACRO_MODE_MECA.

1 Problem of reference

1.1 Geometry

the case test is a metal frame made up of beams and columns.



Coordinates of the principal nodes of mesh:

	Not coordinated. X (in m)	Coordinated. Y (in m)	Coordinated. Z (in m)
A	2.0.2.5.0.0		
B	4.0.0.0.0.0		
C	2.0	– 2.5.0.0.0.0	
D		0.0.0.0.2.0	
E		2.5.3.0.4.0	
F		0.0.3.0.2.0	
G		– 2.5.3.0.0.0	
H		0.0.3.0.2.0	
I		0.0.3.0	

1.2 mechanical Characteristics of the beams

the beams of the case test are standard sections of the metal structure. The units of their mechanical characteristics are homogeneous with meters.

	HEA200	*IPE220*	*IPE160*	*HEA140*	*IPE120*
Beams	*BF , DH*	*HF*	*EI , CG*	*AE*	*FG , GH*
A	5.39E – 03	3.34E – 03	2.01E – 03	3.14E – 03	1.32E – 03
IY	3.69E – 05	2.77E – 05	8.70E – 06	1.03E – 05	3.18E – 06
IZ	1.34E – 05	2.05E – 06	6.83E – 07	3.89E – 06	2.77E – 07
AY	1.474994	1.789865	1.792884	1.464032	1.774392
AZ	4.466038	2.633754	2.586199	4.464173	2.590182
JX	1.97E – 07	8.66E – 08	3.37E – 08	7.76E – 08	1.63E – 08
JG	1.06E – 07	2.23E – 08	3.89E – 09	1.47E – 08	8.73E – the 10

quantities EY EZ $IYR2$, $IZR2$ are null for all the beams.

1.3 Properties of the material

Only one material is used:

Young	$2.10\text{e}+11\ Pa$
Rho	$7.85\text{e}+03\ kg/m^3$

1.4 Boundary conditions

the points A , B , C , D are clamped.

$$DX=0 \quad DY=0 \quad DZ=0 \quad DRX=0 \quad DRY=0 \quad DRZ=0$$

2 Reference solution

2.1 Méthode de calcul used for the reference solution

the values of the reference solution are obtained with the frame, produced with a model containing POU_D_E.

2.2 Results of reference

values obtained by the command POST_ELEM, with key word MASS_INER:

Quantities	Value
MASSE	5.85759E+02
CDG_X	2.00000E+00
CDG_Z	2.03968E+00
IX_PRIN_G	1.56562E+03
IY_PRIN_G	1.81822E+03
IZ_PRIN_G	2.23486E+03

the table below gives the eigen modes calculated with a model of POU_D_E. The modes are filtered by the command EXTR_MODE with criterion MASS_EFFE_UN and a threshold of 5.0E-04.

NUMERICAL MODE	FREQUENCY	MASS_EFFE_UN DX	CUMUL_DX	MASS_EFFE_UN DY	CUMUL_DY	MASS_EFFE_UN DZ	CUMUL_DZ
1	1.00E+01	2.41E – 01	2.41E – 01	1.69E – 26	1.69E – 26	7.04E – 30	7.04E – 30
2	1.24E+01	4.33E – 01	6.74E – 01	3.99E – 24	4.01E – 24	2.64E – 27	2.65E – 27
3	1.31E+01	3.84E – 24	6.74E – 01	5.29E – 01	5.29E – 01	4.13E – 04	4.13E – 04
4	1.75E+01	7.73E – 04	6.74E – 01	4.54E – 26	5.29E – 01	2.74E – 28	4.13E – 04
5	1.91E+01	7.92E – 02	7.54E – 01	1.88E – 27	5.29E – 01	4.25E – 28	4.13E – 04
6	2.24E+01	6.29E – 27	7.54E – 01	1.38E – 01	6.67E – 01	2.22E – 04	6.35E – 04
7	2.69E+01	1.21E – 29	7.54E – 01	6.00E – 02	7.27E – 01	1.50E – 07	6.35E – 04
10	3.36E+01	2.42E – 30	7.54E – 01	6.37E – 04	7.27E – 01	6.26E – 06	6.41E – 04
13	3.53E+01	1.67E – 03	7.55E – 01	7.43E – 30	7.27E – 01	1.13E – 29	6.41E – 04
14	3.70E+01	1.21E – 02	7.68E – 01	9.09E – 30	7.27E – 01	2.84E – 33	6.41E – 04

2.3 Uncertainty on the solution

Without object.

3 Modelization A

3.1 Characteristic of the modelization and the mesh

The model is composed of POU_D_TGM (multifibre beams). All the sections, are in form of "I" and are described with 30 fibers: 1 in the flange and web thickness, 10 in the width of flanges and 10 in the height of the heart.

3.2 Quantities tested and results

the table below summarizes the results got by commands POST_ELEM, with key word MASS_INER, for the model POU_D_TGM and the compared to values of reference obtained with a model of POU_D_E.

Quantities	Values References	Values POU_D_TGM	Relative Error
MASSE	5.8576E+02	5.8576E+02	– 7.04E – 07
CDG_X	2.0000E+00	2.0000E+00	0.00E+00
CDG_Z	2.0397E+00	2.0397E+00	– 2.16E – 06
IX_PRIN_G	1.5656E+03	1.5656E+03	– 1.11E – 06
IY_PRIN_G	1.8182E+03	1.8182E+03	1.80E – 07
IZ_PRIN_G	2.2349E+03	2.2349E+03	– 4.72E – 07

In this test, the authorized maximum relative error is fixed at 2.0E-05.

The table below gives the eigen modes calculated with a model of POU_D_TGM. The modes are filtered by the command EXTR_MODE with criterion MASS_EFFE_UN and a threshold of 5.0E-04. The maximum relative error authorized on the computation of the frequencies is fixed at 2.0E-02. The maximum absolute error authorized on the computation of the MASS_EFFE_UN is fixed at 1.0E-02.

NUMERICAL MODE	FREQUENCY	MASS_EFFE_UN DX	CUMUL_DX	MASS_EFFE_UN DY	CUMUL_DY	MASS_EFFE_UN DZ	CUMUL_DZ
1	1.00E+01	2.45E – 01	2.45E – 01	1.38E – 27	1.38E – 27	7.12E – 31	7.12E – 31
2	1.23E+01	4.30E – 01	6.75E – 01	1.28E – 25	1.30E – 25	7.59E – 29	7.66E – 29
3	1.29E+01	1.10E – 25	6.75E – 01	5.35E – 01	5.35E – 01	4.02E – 04	4.02E – 04
4	1.73E+01	1.90E – 03	6.77E – 01	4.08E – 28	5.35E – 01	5.99E – 31	4.02E – 04
5	1.91E+01	7.67E – 02	7.54E – 01	2.18E – 27	5.35E – 01	3.36E – 30	4.02E – 04
6	2.21E+01	7.04E – 28	7.54E – 01	1.40E – 01	6.75E – 01	2.28E – 04	6.30E – 04
7	2.68E+01	7.31E – 28	7.54E – 01	5.57E – 02	7.31E – 01	1.34E – 07	6.30E – 04
8	3.49E+01	2.32E – 03	7.56E – 01	5.33E – 29	7.31E – 01	2.56E – 31	6.30E – 04
9	3.76E+01	1.72E – 02	7.73E – 01	1.77E – 29	7.31E – 01	8.92E – 34	6.30E – 04

the table below the model compares the results got with POU_D_TGM and the values of reference obtained with a model of POU_D_E (NUME_MODE 1,2,3,5,6,7), for which there are no particular remarks.

	NUMERICAL MODE	FREQUENCY	MASS_EFFE_UN DX	MASS_EFFE_UN DY	MASS_EFFE_UN_DZ
Values references	1	10.0386	2.4062E – 01	1.6855E – 26	7.0440E – 30
POU_D_TG M	1	10.0299	2.4507E – 01	1.3770E – 27	7.1158E – 31
relative Error		– 8.7E –	04.1.8E – 02	---	---
Absolute error		– 8.7E –	03.4.4E – 03	---	---
Values references	2	12.3631	4.3310E – 01	3.9884E – 24	2.6399E – 27
POU_D_TGM	2	12.2722	4.3008E – 01	1.2845E – 25	7.5937E – 29
relative Error		– 7.4E – 03	– 7.0E – 03	---	---
Absolute error		– 9.1E – 02	– 3.0E – 03	---	---
Values references	3	13.0613	3.8389E – 24	5.2880E – 01	4.1267E – 04
POU_D_TGM	3	12.8877	1.1018E – 25	5.3471E – 01	4.0172E – 04
relative Error		– 1.3E – 02	---	1.1E – 02	– 2.7E – 02
Absolute error		– 1.7E – 01	---	5.9E – 03	– 1.1E – 05
Values references	5	19.1421	7.9213E – 02	1.8759E – 27	4.2482E – 28
POU_D_TGM	5	19.0752	7.6706E – 02	2.1807E – 27	3.3632E – 30
relative Error		– 3.5E – 03	– 3.3E – 02	---	---
Absolute error		– 6.7E – 02	– 2.5E – 03	---	---
Values references	6	22.359	6.2877E – 27	1.3777E – 01	2.2223E – 04
POU_D_TGM	6	22.1023	7.0371E – 28	1.4041E – 01	2.2790E – 04
relative Error		– 1.2E – 02	---	1.9E –	02.2.5E – 02
Absolute error		– 2.6E – 01	---	2.6E –	03.5.7E – 06
Values references	7	26.9214	1.2099E – 29	6.0029E – 02	1.5014E – 07
POU_D_TGM	7	26.7993	7.3140E – 28	5.5675E – 02	1.3418E – 07
relative Error		– 4.6E – 03	---	– 7.8E – 02	---
Absolute error		– 1.2E – 01	---	– 4.4E – 03	---

The table below the model compares the results got with POU_D_TGM and the values of reference obtained with a model of POU_D_E (NUME_MODE 4,8,9) for which some remarks are necessary.

	NUMERICAL MODE	FREQUENCY	MASS_EFFE_UN DX	MASS_EFFE_UN DY	MASS_EFFE_UN_DZ
Values references	4	17.53	7.7262E – 04	4.5440E – 26	2.7423E – 28
POU_D_TGM	4	17.3126	1.9020E – 03	4.0831E – 28	5.9912E – 31
relative Error		– 1.3E –	02.5.9E – 01	---	---
Absolute error		– 2.2E –	01.1.1E – 03	---	---
Values references	13	35.2798	1.6712E – 03	7.4262E – 30	1.1337E – 29
POU_D_TGM	8	34.9301	2.3155E – 03	5.3345E – 29	2.5636E – 31
relative Error		– 1.0E –	02.2.8E – 01	---	---
Absolute error		– 3.5E –	01.6.4E – 04	---	---
Values references	14	37.0148	1.2125E – 02	9.0891E – 30	2.8395E – 33
POU_D_TGM	9	37.6334	1.7201E – 02	1.7660E – 29	8.9176E – 34
relative Error		1.6E –	02.3.0E – 01	---	---
Absolute error		6.2E –	01.5.1E – 03	---	---

For the NUME_MODE 4, the frequency is correct, on the other hand there are a relative error of 59% on the MASS_EFFE_UN_DX (1.9E-03 to be compared with 7.7E-04), and an absolute error of 1.1E-03. The value of MASS_EFFE_UN_DX indicates a weak participation of this mode to the dynamic response of structure. The two analyses are thus in agreement, there is a mode in the vicinity of 17.5Hz , and its contribution is very weak with respect to the dynamic response of structure.

After analysis of the results, the mode calculated with 34.9Hz (NUME_MODE 8 for the model POU_D_TGM) corresponds to the mode of reference to 35.3Hz (NUME_MODE 13). On the other hand there exists a relative error of 28% on the MASS_EFFE_UN_DX (2.3E-03 to be compared with 1.7E-03) and an absolute error of 6.4E-04. The value of MASS_EFFE_UN_DX indicates a weak participation of this mode to the dynamic response of structure, the two analyses are thus in agreement.

After analysis of the results, the mode calculated with 37.6Hz (NUME_MODE 9 for the model POU_D_TGM) corresponds to the mode of reference to 37.0Hz (NUME_MODE 14). On the other hand there exists a relative error of 30% on the MASS_EFFE_UN_DX (1.7E-02 to be compared with 1.2E-02) and an absolute error of 5.1E-03. The value of MASS_EFFE_UN_DX indicates a weak participation of this mode to the dynamic response of structure, the two analyses are thus in agreement.

Mode, of the reference solution, which corresponds to the frequency of 33.6Hz (NUME_MODE 10) is not found by the modelization in POU_D_TGM. Mass MASS_EFFE_UN_DY, corresponding to this mode is of 6.37E-04, lower than 0.1%. This value indicates a weak participation of this mode to the dynamic response of structure. The fact that one does not find this mode, with a modelization of POU_D_TGM, will thus not influence the dynamic analysis which one could analyze thereafter.

4 Summary of the results

the results of reference are got with a model of POU_D_E.
The analyses carried out with a modelization in POU_D_TGM are in agreement with the reference solution.