SDLL108 - “Table with coffee” of NEUBERT

Summary

This multidirectional problem consists in carrying out a spectral seismic analysis of a structure made up of elements of beams without masses and discrete masses to the nodes. It understands a modeling.

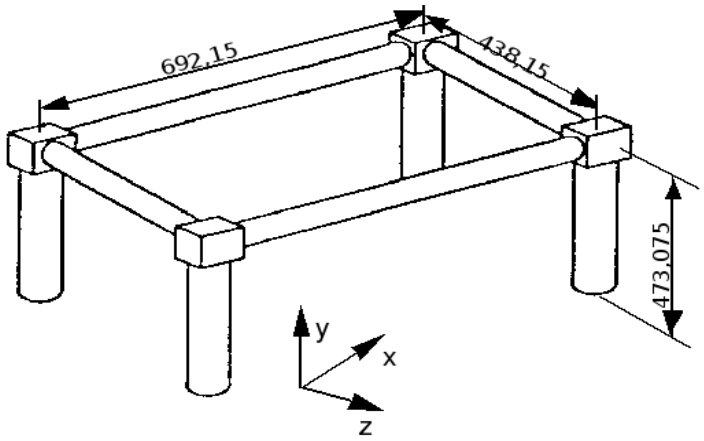
The seismic excitation is provided in the shape of three spectra of response of oscillators in acceleration to the supports according to the axes X , Y and Z .

Via this problem, the order is tested MODE_STATIQUE and options of quadratic combination of the modes and quadratic combination and combination of Newmark of the directions of the excitations of the order COMB_SISM_MODAL.

The got results are in concord with the results of reference got with the code HERCULES.

1 Problem of reference

1.1 Geometry



$L = 0.69215\, m$
$l = 0.43815\, m$
$H = 0.473075\, m$

Hollow circular section:
$d_e = 0.060\, m$
$d_i = 0.052\, m$
$S = 0.7037\, 10^{-3}\, m^2$
$I_y = I_z = 0.2772\, 10^{-6}\, m^4$
$A_y = A_z = 2.$
$C_y = 0.5545\, 10^{-6}\, m^4$

1.2 Material properties

$E = 1.92276\, EIIN / m^2$
$\nu = 0.3$
$\rho = 7800.0\, kg / m^3$

Four masses of $4.444\, kg$ are localised at the four higher tops, to see figure.

1.3 Boundary conditions and loadings

- Structure embedded at its base,
- Modal depreciation of $2\,\%$.

Definition of the spectrum of acceleration to the supports

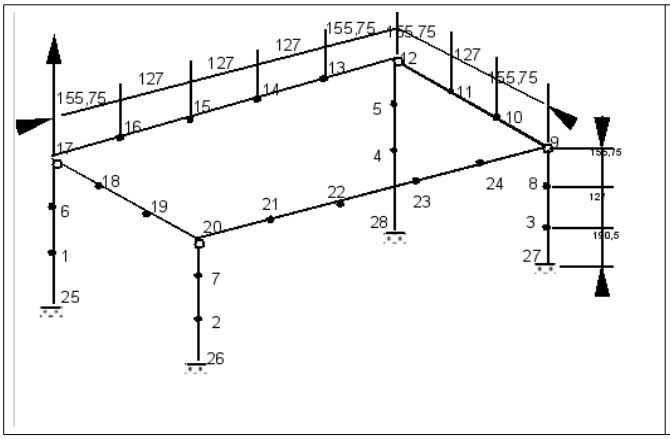
Frequency	X Z	Y
100	17.3	11.5
110	16.3	10.9
120	15.3	10.2
130	14.3	9.6
300	10.2	6.66

- for a damping of $2\,\%$,
- acceleration in g .

2 Reference solution

2.1 Method of calculating used for the reference solution

The results of reference were got at the same time in an experimental way [1] and with the code HERCULES [2]. The model finite elements used is identical has that used for the modeling A carried out with *Code_Aster*.



Mesh: $1019 : N6-N17$
$1009 : N17-N18$
$1008 : N17-N16$

Masses of the corners: $4.444\,kg$
Intermediate masses: $0.783\,kg$

The geometrical dimensions used in calculations with HERCULES are very slightly different from those presented to the §1.1:

- $L=692.50\,mm$; $l=438.50\,mm$; $H=473.25\,mm$

2.2 Results of reference

- Eigen frequencies
- Displacements at the points constituting the corners of the table,
- Reactions of supports to anchorings,
- Internal efforts with the “corners”.

Identification	**Reference [feeding-bottle-1] experimental**	**Reference [feeding-bottle-2] Hercules**	**Effective masses** (% of the total mass)		
Mode	Frequency (Hz)	Frequency (Hz)	X	Y	Z
1	110.0	110,857	94.2	0.0	0.0
2	117.0	115,471	0.0	0.0	94.4
3	134.0	135,936	0.0	0.0	0.0
4	214.0	213,541	0.0	0.0	0.0
5	416.0	417,332	0.0	0.0	0.0
6		434,813	0.0	24.1	0.0
7		464,097	0.0	0.0	0.0
8	553.0	557,262	0.0	0.0	0.3
9	821.0	821,746	0.0	18.0	0.0
10		847,071	0.0	0.0	0.0
11	927.0	978,174	1.6	0.0	0.0
12		991,842	0.0	2.2	0.0
13		1021.669	1.8	0.0	0.0
14		1040.240	0.0	0.0	0.0
15		1056.948	0.0	0.0	0.2
16		1088.861	0.0	18.8	0.0

17		1093.157	1.2	0.0	0.0
18		1107.870	0.0	0.0	0.0

Identification		Values obtained with combination	
		quadratic of the directions of the excitations	NEWMARK of the directions of the excitations
Displacement:			
$N17$	$DX(m)$	3.4246E-04	3.4265E-04
	$DY(m)$	4.3562E-06	4.8392E-06
	$DZ(m)$	3.0321E-04	3.0324E-04
	$DRX(rad)$	3.7031E-04	3.7612E-04
	$DRY(rad)$	4.7665E-05	5.2602E-05
	$DRZ(rad)$	5.1104E-04	5.2310E-04
Reactions:			
$N25$	$FX(N)$	1.2536E+03	1.2790E+03
	$FY(N)$	1.2473E+03	1.3868E+03
	$FZ(N)$	1.2196E+03	1.2441E+03
	$MX(N.m)$	3.2474E+02	3.2789E+02
	$MY(N.m)$	4.1310E+00	4.5579E+00
	$MZ(N.m)$	3.4846E+02	3.5199E+02
Efforts:			
1019 $N17$	$FX(N)$	1.1312E+03	1.1486E+03
	$FY(N)$	1.2431E+03	1.3793E+03
	$FZ(N)$	1.0982E+03	1.1141E+03
	$MX(N.m)$	2.2833E+02	2.2982E+02
	$MY(N.m)$	4.1301E+00	4.5580E+00
	$MZ(N.m)$	2.2068E+02	2.2537E+02
1009 $N17$	$FX(N)$	1.8813E+02	2.0079E+02
	$FY(N)$	1.0419E+03	1.0650E+03
	$FZ(N)$	1.3175E+02	1.4833E+02
	$MX(N.m)$	2.2833E+02	2.2975E+02
	$MY(N.m)$	2.9165E+01	3.2490E+01
	$MZ(N.m)$	1.6408E-01	1.6400E-01
1008 $N17$	$FX(N)$	2.9587E+02	3.3579E+02
	$FY(N)$	6.3879E+02	6.7526E+02
	$FZ(N)$	2.6539E+02	2.7947E+02
	$MX(N.m)$	1.8400E-01	1.8500E-01
	$MY(N.m)$	3.2361E+01	3.5570E+01
	$MZ(N.m)$	2.2068E+02	2.2535E+02

Remarks

- Displacements of the corners $(N9, N12, N17, N20)$ are identical,
- Reactions to the supports $(N25, N26, N27, N28)$ are identical,
- The generalized efforts are expressed in the total reference mark.

2.3 Bibliographical references

1) NEUBERT V.H. and EZELL W.H.: Dynamic behavior of has foundation like structure. ASME Colloquium one Mechanical Impedance Methods for Mechanical Vibrations, pp. 77-86, 1958.

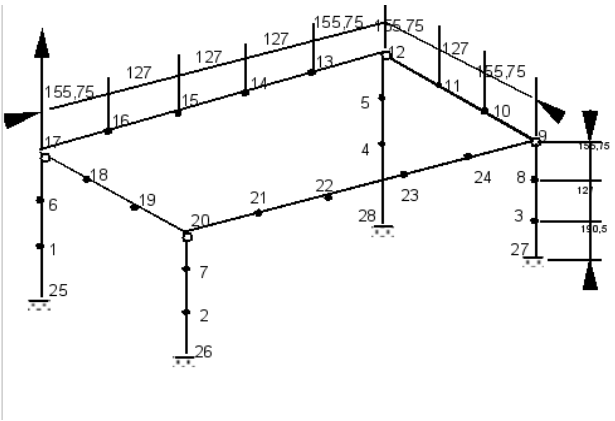
2) HERCULES: computer code by finite elements for the civil engineer developed by SOCOTEC.

3 Modeling A

Modeling A is identical to modeling B. Its interest consists in validating the key word FREQ_COUP, which makes it possible to enter the frequency to which one will read on the SRO the static level of correction of the seismic answer.

4 Modeling B

4.1 Characteristics of modeling



Mesh $E3$: $N6-N17$
$E4$: $N17-N18$
$E19$: $N17-N16$

Masses of corners : $4.444\,kg$

Intermediate masses : $0.783\,kg$

4.2 Characteristics of the grid

Many nodes: 28

Many meshs and types: 52 (28 MECA_POU_D_T and 24 MECA_DIS_T_N)

4.3 Remarks

The modes are standardized with the generalized mass with 1.

The total answer is obtained by quadratic combination of the modes, then successively a quadratic combination and a combination of Newmark of the directions of the excitations.

4.4 Values tested: frequencies

Identification	Reference	% tolerance
Mode	Frequency (Hz)	
1	110,857	.1
2	115,471	.1
3	135,936	.1
4	213,541	.1
5	417,332	.1
6	434,813	.1
7	464,097	.1
8	557,262	.2
9	821,746	.1
10	847,071	.1
11	978,174	.2
12	991,842	.1
13	1021.669	.1
14	1040.240	.1
15	1056.948	.1
16	1088.861	.1
17	1093.157	.1
18	1107.870	.1

4.5 Values tested with quadratic combination of the directions of the excitations

Identification	Reference	% tolerance
Displacement:		
$N17 \quad DX(m)$	3.4246E-04	2.
$DY(m)$	4.3562E-06	2.
$DZ(m)$	3.0321E-04	2.
$DRX(rad)$	3.7031E-04	2.
$DRY(rad)$	4.7665E-05	2.
$DRZ(rad)$	5.1104E-04	2.
Reactions REAC_NODA :		
$N25 \quad FX(N)$	1.2536E+03	2.
$FY(N)$	1.2473E+03	2.
$FZ(N)$	1.2196E+03	2.
$MX(N.m)$	3.2474E+02	2.
$MY(N.m)$	4.1310E+00	2.
$MZ(N.m)$	3.4846E+02	2.
Efforts EFGE_ELNO :		
$E3 \quad N17 \quad FX(N)$	1.1312E+03	2.
$FY(N)$	1.2431E+03	2.
$FZ(N)$	1.0982E+03	2.
$MX(N.m)$	2.2833E+02	-2.
$MY(N.m)$	4.1301E+00	2.
$MZ(N.m)$	2.2068E+02	2.
$E4 \quad N17 \quad FX(N)$	1.8813E+02	2.
$FY(N)$	1.0419E+03	2.
$FZ(N)$	1.3175E+02	2.
$MX(N.m)$	2.2833E+02	2.
$MY(N.m)$	2.9165E+01	2.
$MZ(N.m)$	1.6408E-01	2.
$E19 \quad N17 \quad FX(N)$	2.9587E+02	2.
$FY(N)$	6.3879E+02	2.
$FZ(N)$	2.6539E+02	2.
$MX(N.m)$	1.8400E-01	2.
$MY(N.m)$	3.2361E+01	2.
$MZ(N.m)$	2.2068E+02	2.

4.6 Values tested with combination of NEWMARK of the directions of the excitations

Identification	Reference	% tolerance
Displacement:		
$N17 \quad DX(m)$	3.4265E-04	2.
$DY(m)$	4.8392E-06	2.
$DZ(m)$	3.0324E-04	2.
$DRX(rad)$	3.7612E-04	**2.**
$DRY(rad)$	5.2602E-05	2.
$DRZ(rad)$	5.2310E-04	2.
Reactions REAC_NODA :		
$N25 \quad FX(N)$	1.2790E+03	2.
$FY(N)$	1.3868E+03	2.
$FZ(N)$	1.2441E+03	2.
$MX(N.m)$	3.2789E+02	2.
$MY(N.m)$	4.5579E+00	2.
$MZ(N.m)$	3.5199E+02	2.
Efforts EFGE_ELNO :		
$E3 \quad N17 \quad FX(N)$	1.1486E+03	2.
$FY(N)$	1.3793E+03	2.
$FZ(N)$	1.1141E+03	2.
$MX(N.m)$	2.2982E+02	2.
$MY(N.m)$	4.5580E+00	2.
$MZ(N.m)$	2.2537E+02	2.
$E4 \quad N17 \quad FX(N)$	2.0079E+02	2.
$FY(N)$	1.0650E+03	2.
$FZ(N)$	1.4833E+02	2.
$MX(N.m)$	2.2975E+02	2.
$MY(N.m)$	3.2490E+01	2.
$MZ(N.m)$	1.6400E-01	2.
$E19 \quad N17 \quad FX(N)$	3.3579E+02	2.
$FY(N)$	6.7526E+02	2.
$FZ(N)$	2.7947E+02	2.
$MX(N.m)$	1.8500E-01	2.
$MY(N.m)$	3.5570E+01	2.
$MZ(N.m)$	2.2535E+02	2.

- Displacements of the corners $(N9, N12, N17, N20)$ are identical,
- Reactions to the supports $(N25, N26, N27, N28)$ are identical,
- The generalized efforts are expressed in the total reference mark.

5 Summary of the results

One obtains a relatively good agreement between the solution calculated with *Code_Aster* and the solution calculated by HERCULES:

- Frequencies: the variations observed for the first 18 frequencies are weak, lower than 0.2% .
- Displacements: the variations observed are lower than 1% if one uses a quadratic combination of the directions of the excitations, and lower than $2\ \%$ if one uses a combination of Newmark of the directions of the excitations.
- Efforts: the variations observed are lower than 2% .