SDLL08 - Netting plan of beams (metal sections)

Summary:

This three-dimensional problem first of all consists in carrying out a modal analysis and then to study the harmonic answer of a mechanical structure of a netting plan of beams. This test of Mechanics of the Structures corresponds to a dynamic analysis of a linear model having a linear behavior. It understands only one modeling.

This problem thus makes it possible to test the element of beam of Euler Bernouilli in transverse inflection, the calculation of the frequencies and the modes of vibration by the method of Lanczos and the use of linear relations between displacements of two points in modal analysis and harmonic answer.

The results are in agreement with the analytical results of guide VPCS.

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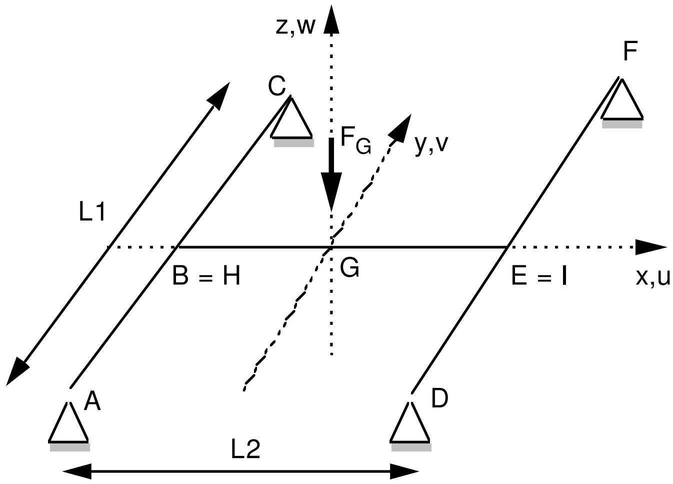
1 Problem of reference

1.1 Geometry



Length: $L1=L2=5\,m$

Cross-section (section in I): $IPE\,200$

surface $A=2.872\,10^{-3}\,m^2$

moment of inertia $Iz=1.943\,10^{-5}\,m^4$

(other parameters of beam not used)

Coordinates of the points (in meters):

	A	$B=H$	C	D	$E=I$	F	G
x	– 2.5	– 2.5	– 2.5	2.5	2.5	2.5	0
y	– 2.5	0.	2.5	– 2.5	0.	2.5	0.
z	0.	0.	0.	0.	0.	0.	0.

1.2 Material properties

$E=2.10^{11}\,Pa$

$\rho=7\,800.\,kg/m^3$

1.3 Boundary conditions and loadings

Points A,C,D,F : ($u=v=w=0.$)

Points B,E : rotulée connection (continuity of u,v,w)

Force sinusoïdale au point G $F_G(t)=F_0\sin\Omega t$

$F_0=-1\cdot10^5\,N$

$\Omega=80\text{ rad/ s}$

1.4 Initial conditions

With $t=0$, structure at rest.

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2 Reference solution

2.1 Method of calculating used for the reference solution

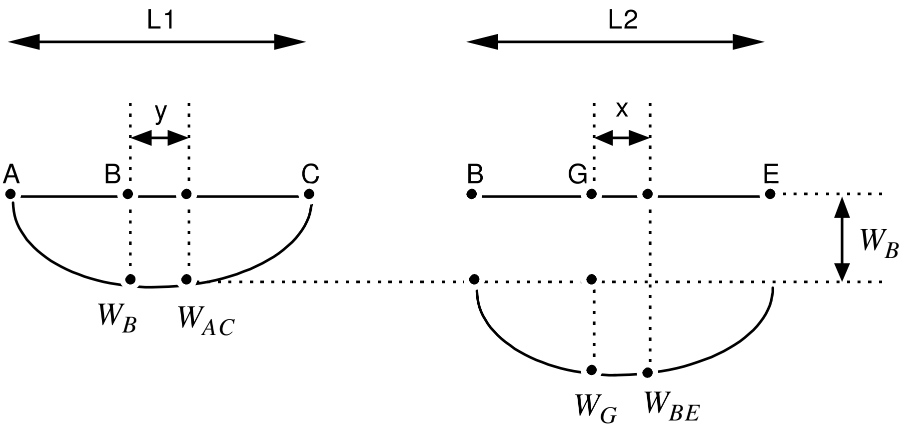
The reference solution is that given in card SDLL08/89 of the guide VPCS which presents the method of calculating in the following way:
A method of Rayleigh-Ritz makes it possible to calculate with two degrees of freedom starting from the assumptions of following symmetrical deformations:

- for the point of X-coordinate y members AC and DF of length $L1$

$$W_{AB} = W_B \sin \frac{\pi \left(y + \frac{L1}{2} \right)}{L1}$$

- for the point of X-coordinate x cross-piece BE of length $L2$

$$W_{BE} = W_B + W_G \sin \frac{\pi \left(x + \frac{L2}{2} \right)}{L2}$$



2.2 Results of reference

The first two Eigen frequencies and clean modes **symmetrical** (the other Eigen frequencies of this system are not studied). For the clean modes, one has the following value: W_B / W_G

In harmonic answer one a:

- $W_B \max$ et $W_G \max$,
- $W_B + W_G \max$ at the point G.

2.3 Uncertainty on the solution

Analytical solution.

2.4 Bibliographical references

1) J.M. BIGGS. Introduction to Structural Dynamics. New York: Mc Graw Hill, p.184 (1964).

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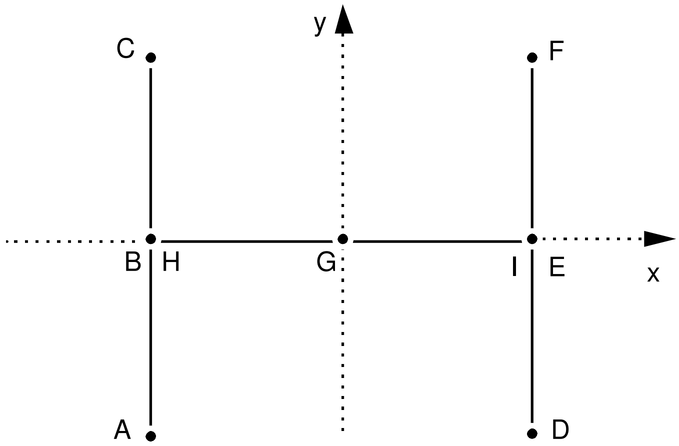
3 Modeling A

3.1 Characteristics of modeling

One uses the element of beam of Euler Bernouilli `POU_D_E`



3 beams: ABC , DEF , HGI cut out each one in 10 meshs SEG2
Nodes (B, H) and (E, I) the same coordinates have.

Limiting conditions:
beams ABC and DEF
`DDL_IMPO`: (GROUP_NO: (PABC, PDEF) DX: 0. , DY: 0. , DRY MARTINI: 0.)
beam HGI
nodes ends
(GROUP_NO: (PHGI) DX: 0. , DY: 0. , DRX: 0.)
(GROUP_NO: (NACDF) DZ: 0.)

Liaison_ddl: $DZ_B - DZ_H = 0.$ and $DZ_E - DZ_I = 0.$
Force_nodale: Node: G Fz : $-1.E5$

Names of the nodes:

$A = N1$	$B = N6$	$C = N11$
$D = N21$	$E = N26$	$F = N31$
$H = N41$	$G = N46$	$I = N51$

3.2 Characteristics of the grid

Many nodes: 33
Many meshs and types: 3*10 = 30 SEG2

3.3 Remarks

The blocking of the degrees of freedom DX and DY in all the nodes allows to select only the modes of transverse inflection (in the "vertical" plane).

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3.4 Sizes tested and results

Frequency (Hz)

Order of the clean mode	Reference	*Aster*	% difference
1	16,456	16.4190	– 0.22
2	38,165	38.0468	– 0.31

Clean mode: value of W_B / W_G

Order of the symmetrical clean mode	Reference	*Aster**	% difference
1	1,213	1,213	0.
2	– 0,412	– 0,412	0.

*	$W_B = DZ$ in B ($N6$)	$W_G + W_B = DZ$ in G ($N46$)
mode 1:	$W_B = 0.5480$	$W_G + W_B = 1.$
mode 2:	$W_B = -0.6698$	$W_G + W_B = 0.9559$

Harmonic answer:

Not	Type of value (m)	Reference	*Aster*	% difference
B, E	$W_B max$	– 0,098	– 0.1003	2.45
G	$W_G max*$	– 0,125	– 0.1271	1.60
G	$W_B + W_G max$	– 0,227	– 0.2274	0.18

3.5 Remarks

Calculations carried out by:

```
CALC_MODES
            OPTION = 'PLUS_PETITE'
            CALC_FREQ=_F (NMAX_FREQ = 3)
            SOLVEUR_MODAL=_F (METHOD = 'TRI_DIAG')
```

One obtains an antisymmetric mode for a frequency $f = 22.5676\,Hz$. This Eigen frequency depends on the constant of provided torsion; this one is not defined in the bench-mark data.

Values W_B / W_G are not checked in the test but are obtained manually from W_B and $W_G + W_B$. The value (W_G) max is not checked in the test. One has only access to $W_B max$ and $(W_B + W_G) max$. $W_G max$ is obtained manually by difference.

Contents of the file results:

the first 3 Eigen frequencies, displacement of the nodes B, E, G in harmonic answer.

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4 Summary of the results

The values of the Eigen frequencies and the clean vectors are obtained with a precision $< 0.3\%$.

The variation of 2.5% on the maximum arrows at the points B and E would deserve to check the reference solution, to supplement the validation of the harmonic answer.

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