SDLL08 - Fit latticework on plane beams (metal sections)

Summarized:

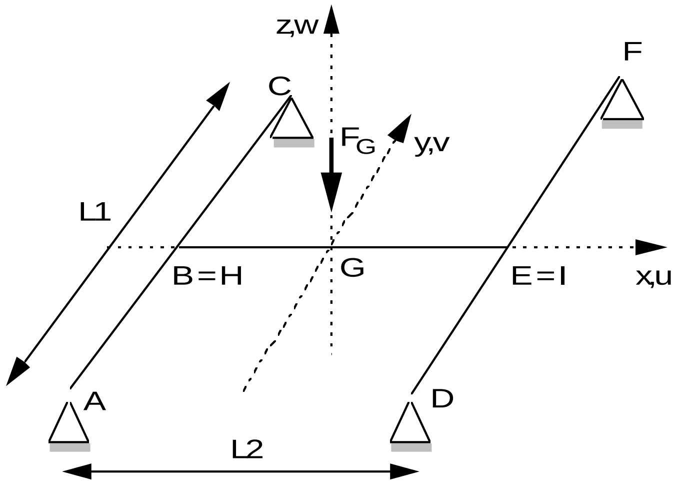
This three-dimensional problem first of all consists in carrying out a modal analysis and then to study the harmonic response of a mechanical structure of a plane netting of beams. This test of Structural mechanics corresponds to a dynamic analysis of a linear model having a linear behavior. It understands only one modelization.

This problem thus makes it possible to test the beam element of Eulerian Bernouilli in transverse bending, the computation 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 response.

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

1 Problem of reference

1.1 Geometry



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

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

area	$A=2.872\,10^{-3}\,m^2$
main moment of inertia	$Iz=1.943\,10^{-5}\,m^4$

(other parameters of beam not used)

Coordinated 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 $F_G(t)=F_0 \sin \Omega t$

$F_0=-1\cdot 10^5\ N$

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

1.4 Initial conditions

A $t=0$, structure at rest.

2 Reference solution

2.1 Method of calculating used for the reference solution

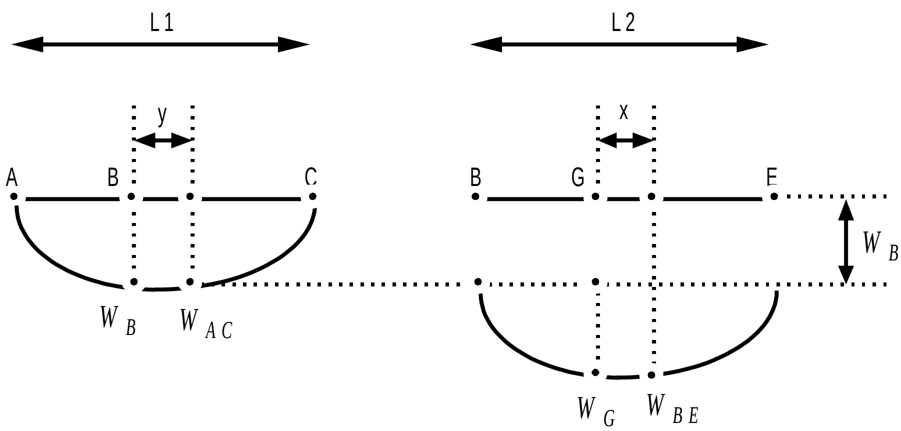
the reference solution is that given in file SDLL08/89 of the guide VPCS which presents the method of calculating in the following way:
A method of Rayleigh-Ritz makes it possible to calculate with two degrees of freedom starting from the assumptions of following symmetric deformed shapes:

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

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

for the point of X-coordinate x of the cross-piece BE 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 symmetric eigenfrequencies and **eigen modes** (the other eigenfrequencies of this system are not studied). For the eigen modes, one has the following value: W_B / W_G

In harmonic response one a:

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

2.3 Uncertainty on the analytical

solution Solution.

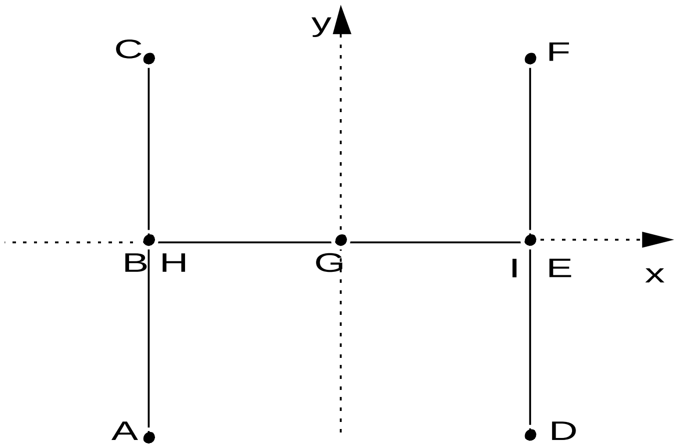
2.4 Bibliographical references

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

3 Modelization A

3.1 Characteristic of the modelization

One uses the beam element of Eulerian Bernouilli `POU_D_E`



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

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

Liaison_ddl: $DZ_B - DZ_H = 0.$ and $DZ_E - DZ_I = 0.$
Force_nodale: The node is outside the field of definition with a right profile of the EXCLU type 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 mesh

Many nodes: 33
Number of meshes and types: 3*10 = 30 SEG2

3.3 Remarks

blocking of the degrees of freedom DX and DY in all the nodes makes it possible to select only the modes of transverse bending (in the “vertical” plane).

3.4 Quantities tested and Frequency

results (Hz)

Order of the eigen mode	Reference	*Aster*	% difference
1	16.456	16.4190	– 0.22
2	38.165	38.0468	– 0.31

Eigen mode: value of W_B/W_G

Order of the symmetric eigen 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 response:

Not	Standard 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

Computations carried out by:

```
MODE_ITER_SIMULTMETHODE: "TRI_DIAG"
                        OPTION: '    PLUS_PETITE'NMAX_FREQ: 3
```

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

The values W_B/W_G are not checked in the test but are obtained manually from W_B and W_G+W_B .

Value (WG) 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 eigenfrequencies, displacement of the nodes B, E, G in harmonic response.

4 Summary of the results

the values of the eigenfrequencies and the eigenvectors are obtained with an accuracy $< 0.3\%$.

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