

Code_Aster

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Titre : SSL11 - Treillis de barres articulées sous charge[...]
Responsable : FLÉJOU Jean-Luc

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SSLL11 - Lattice of pin jointed struts under concentrated loading

Summary:

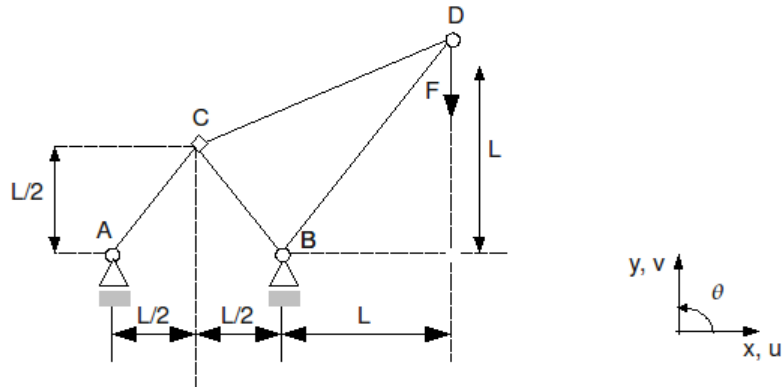
This test makes it possible to check the elements of bar and beam for the structural analysis out of lattice. The lattice considered is plan. Calculation is static, elastic, linear. The reference solution is analytical.

Three modelings make it possible to test the elements `POU_D_T` with and without rotulées connections, as well as the elements `BAR`.

Three modelings make it possible to test the elements `POU_D_TG`, `POU_D_EM` and `POU_D_TGM` with and without rotulées connections.

1 Problem of reference

1.1 Geometry



Length $L = 1\text{ m}$

elements AC and BC of circular section $A = 2 \cdot 10^{-4}\text{ m}^2$

elements CD and BD of circular section $A = 1 \cdot 10^{-4}\text{ m}^2$

Coordinates of the points (in m):

	A	B	C	D
x	0.	1.	0.5	2.
y	0.	0.	0.5	1.
z	0.	0.	0.	0.

1.2 Material properties

Young modulus: $E = 1.962 \cdot 10^{11}\text{ Pa}$

1.3 Boundary conditions and loadings

Nodes A and B are articulated: $u = v = 0$

Vertical specific force in D : $F = -9.81 \cdot 10^3\text{ N}$

2 Reference solution

2.1 Method of calculating used for the reference solution

The reference solution is that given in card SSSL11/89 of guide VPCS.
It is obtained by the method of displacements in [bib1].

2.2 Results of reference

Displacements of the points C and D .

2.3 Uncertainty on the solution

Analytical solution.

2.4 Bibliographical references

[1] RAO (J.S.): The finite element method in engineering , problem 5.1, p. 275.

3 Modeling A

3.1 Characteristics of modeling

Taking into account the twinges, the taking into account of the articulations modifies the results little. For this modeling, articulations in A , B , C and D are rigidified (continuity of the 3 components of generalized efforts).

4 beams of full circular section: 4 meshes SEG2

elements AC and BC ray $R=7.978845 \cdot 10^{-3} m$ (surface $A=2 \cdot 10^{-4} m^2$)

elements CD and BD ray $R=5.641895 \cdot 10^{-3} m$ (surface $A=1 \cdot 10^{-4} m^2$)

Poisson's ratio: $\nu=0.3$

Limiting conditions:

in all them nodes :

```
DDL_IMPO= (
  _F (TOUT=' OUI ', DZ= 0. , DRX= 0. , DRY= 0. ),
  _F (NOEUD= (WITH, B), DX= 0. , DY= 0.)
)
```

Name of nodes : Not $A = A$ Not $C = C$
 Not $B = B$ Not $D = D$

3.2 Characteristics of the grid

Number of nodes : 4

Many meshes and types: 4 SEG2

3.3 Sizes tested and results

Identification	Type of reference	Value	Tolerance
DX at the point C	'ANALYTICAL'	2.65E-04	3.0E-04
DY at the point C	'ANALYTICAL'	0.8839E-04	3.0E-04
DX at the point D	'ANALYTICAL'	3.47902E-03	3.0E-04
DY at the point D	'ANALYTICAL'	- 5.60084E-03	3.0E-04

4 Modeling B

4.1 Characteristics of modeling

4 elements `POU_D_T` of full circular section: 4 meshes `SEG2`

elements `AC` and `BC` ray $R = 7.978845 \cdot 10^{-3} m$ (surface $A = 2 \cdot 10^{-4} m^2$)

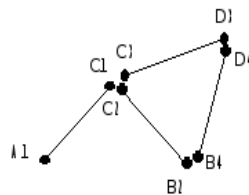
elements `CD` and `BD` ray $R = 5.641895 \cdot 10^{-3} m$ (surface $A = 1 \cdot 10^{-4} m^2$)

Poisson's ratio: $\nu = 0.3$

Limiting conditions:

`DDL_IMPO=_F (Tout=' OUI', DZ= 0. , DRX= 0. , DRY= 0.)`

To treat the rotary joints, one creates as many nodes as of ends of bar.



- with the nodes `A1`, `B2` and `D4` : `DDL_IMPO=_F (Tout=' OUI', DZ= 0. , DRX= 0. , DRY= 0.)`
- with the nodes `C1`, `C2`, `C3` and `D3`, `D4` continuity of the translations, by `LIAISON_DDL DX` and `DY`.
- no rotation is imposed.

4.2 Characteristics of the grid

Many nodes: 4

Many meshes and types: 4 `SEG2`

4.3 Sizes tested and results

Not	Displacement (m)	Type of Reference	Reference	Tolerance
C	u_c	ANALYTICAL	2.6517E-04	3.0E-04
	v_c	ANALYTICAL	0.8839E-04	3.0E-04
D	u_D	ANALYTICAL	3.47902E-03	3.0E-04
	v_D	ANALYTICAL	- 5.60084E-03	3.0E-04

5 Modeling C

5.1 Characteristics of modeling

4 elements BAR of full circular section: 4 meshes SEG2

elements AC and BC ray $R=7.978845 \cdot 10^{-3} m$ (surface $A=2.10^{-4} m^2$)

elements CD and BD ray $R=5.641895 \cdot 10^{-3} m$ (surface $A=1.10^{-4} m^2$)

Poisson's ratio: $\nu=0.3$

Limiting conditions:

```
DDL_IMPO= (
  _F (TOUT=' OUI', DZ= 0. )
  _F (NOEUD= (WITH, B), DX= 0. , DY= 0.)
)
```

5.2 Characteristics of the grid

Many nodes: 4

Many meshes and types: 4 SEG2

5.3 Sizes tested and results

Static calculation:

Not	Displacement (m)	Type of Reference	Reference	Tolerance
C	u_c	ANALYTICAL	2.6517E -04	1.0E-04
	v_c	ANALYTICAL	8.84E-05	1.0E-04
D	u_D	ANALYTICAL	3.47902E-03	1.0E-04
	v_D	ANALYTICAL	- 5.60084E-03	1.0E-04

Harmonic calculation:

Not	Field	Freq.	Comp	Type of Reference	Reference	Tolerance
C	DEPL	100	DX	NOT REGRESSION	4.01805E-08 - 4.21987E-06j	1.0E-03
C	DEPL	100	DY	NOT REGRESSION	1.66019E-08-1.406541E-06j	1.0E-03
D	DEPL	100	DX	NOT REGRESSION	5.81263E-07-5.53643E-05j	1.0E-03
D	DEPL	100	DY	NOT REGRESSION	-9.72590E-7+8.91215E-5j	1.0E-03
D	QUICKLY	100	DX	NOT REGRESSION	0.03478 + 3.652186E-04j	1.0E-03
D	QUICKLY	100	DY	NOT REGRESSION	-0.05599 - 6.11096E-04j	1.0E-03
D	ACCE	100	DX	NOT REGRESSION	-0.22947 + 21.85696j	1.0E-03
D	ACCE	100	DY	NOT REGRESSION	0.383963 - 35.1837j	1.0E-03
B	EFGE_ELNO	100	NR	NOT REGRESSION	-3.83891 + 331.15804j	1.0E-03
D	EFGE_ELNO	100	NR	NOT REGRESSION	-3.83891 + 331.15804j	1.0E-03

6 Modeling D

6.1 Characteristics of modeling

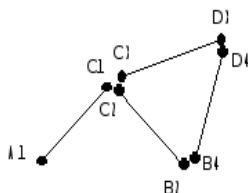
4 elements `POU_D_TG` of hollow circular section: 4 meshes `SEG2`

elements <i>AC</i> and <i>BC</i>	ray: $R=8.305164 \cdot 10^{-3} m$ Thickness: $e=0.006 m$	surface $A=2 \cdot 10^{-4} m^2$
elements <i>CD</i> and <i>BD</i>	ray: $R=5.683099 \cdot 10^{-3} m$ Thickness: $e=0.005 m$	surface $A=1 \cdot 10^{-4} m^2$
Poisson's ratio:	$\nu=0.3$	

Limiting conditions:

`DDL_IMPO= (Tout=' OUI', DZ=0. , DRX=0. , DRY=0.)`

To treat the rotary joints, one creates as many nodes as of ends of bar.



- with the nodes *A1*, *B2* and *D4* : `DDL_IMPO=_F (Tout=' OUI', DX= 0. , D4= 0. ,)`
- with the nodes *C1*, *C2*, *C3* and *D3*, *D4* continuity of the translations, by `LIAISON_DDL DX` and `DY`.
- no rotation is imposed.

6.2 Characteristics of the grid

Many nodes: 8
Many meshes and types: 4 `SEG2`

6.3 Remarks

In this modeling one calculates the dynamic response complexes system subjected to a complex harmonic excitation ($F = -9810. + 0.j$) in the presence of a viscous damping proportional to rigidity and the mass. (`AMOR_ALPHA=AMOR_BETA=0.1`). The results are compared with the results got with modeling `POU_D_T`.

6.4 Sizes tested and results

The results (Displacement, Speed and Acceleration) were got at a frequency of 100 Hz

Not	Displacement (m)	Type of Reference	Reference	Tolerance
<i>D</i>	<i>DX</i>	NOT REGRESSION	-1.65073E-05-9.22424E-06j	1,00E-003
	<i>DY</i>	NOT REGRESSION	2.52829E-05+1.80184E-05j	1,00E-003
Not	Speed (m/s)	Type of Reference	Reference	Tolerance
<i>D</i>	<i>DX</i>	NOT REGRESSION	5.79576E-03-1.03719E-02j	1,00E-003
	<i>DY</i>	NOT REGRESSION	-1.13213E-02+1.58857E-02j	1,00E-003
Not	Acceleration (m/s ²)	Type of Reference	Reference	Tolerance
<i>D</i>	<i>DX</i>	NOT REGRESSION	6.51684+3.64158j	1,00E-003
	<i>DY</i>	NOT REGRESSION	-9.98130-7.11336j	1,00E-003

7 Modeling E

7.1 Characteristics of modeling

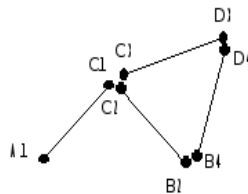
4 elements `POU_D_EM` of hollow circular section: 4 meshes `SEG2`

elements <i>AC</i>	and ray: $R=8.305164 \cdot 10^{-3} m$	surface
<i>BC</i>	Thickness: $e=0.006 m$	$A=2 \cdot 10^{-4} m^2$
elements <i>CD</i>	and ray: $R=5.683099 \cdot 10^{-3} m$	surface
<i>BD</i>	Thickness: $e=0.005 m$	$A=1 \cdot 10^{-4} m^2$
Poisson's ratio:	$\nu=0.3$	

Limiting conditions:

`DDL_IMPO= (Tout=' OUI', DZ= 0. , DRX= 0. , DRY= 0.)`

To treat the rotary joints, one creates as many nodes as of ends of bar.



- with the nodes *A1* , *B2* and *D4* : `DDL_IMPO=_F (Tout=' OUI', DX= 0. , D4= 0. ,)`
- with the nodes *C1* , *C2* , *C3* and *D3* , *D4* continuity of the translations, by `LIAISON_DDL DX` and `DY`.
- no rotation is imposed.

7.2 Characteristics of the grid

Many nodes: 8

Many meshes and types: 4 `SEG2`

Grid of the two hollow sections		
Elements	Grid	Characteristics
<i>AC</i> and <i>BC</i>		240 nodes 79 <code>SEG2</code> 415 <code>TRIA3</code>
<i>CD</i> and <i>BD</i>		127 nodes 56 <code>SEG2</code> 210 <code>TRIA3</code>

7.3 Remarks

In this modeling one calculates the dynamic response complexes system subjected to a complex harmonic excitation ($F = -9810. + 0.j$) in the presence of a viscous damping proportional to rigidity and the mass. ($AMOR_ALPHA = AMOR_BETA = 0.1$). The results are compared with the results got with modeling POU_D_T.

7.4 Sizes tested and results

The results (Displacement, Speed and Acceleration) were got at a frequency of 100 Hz

Not	Displacement (m)	Type of Reference	Reference	Tolerance
D	DX	AUTRE_ASTER	-1.65073E-05-9.22424E-06j	3.50%
	DY	AUTRE_ASTER	2.52829E-05+1.80184E-05j	3.00%

Not	Speed (m/s)	Type of Reference	Reference	Tolerance
D	DX	AUTRE_ASTER	5.79576E-03-1.03719E-02j	3.50%
	DY	AUTRE_ASTER	-1.13213E-02+1.58857E-02j	3.00%

Not	Acceleration (m/s ²)	Type of Reference	Reference	Tolerance
D	DX	AUTRE_ASTER	6.51684+3.64158j	3.50%
	DY	AUTRE_ASTER	-9.98130-7.11336j	3.00%

8 Modeling F

8.1 Characteristics of modeling

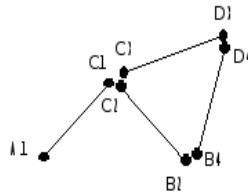
4 elements `POU_D_TGM` of hollow circular section: 4 meshes `SEG2`

elements AC and BC	ray: $R=8.305164 \cdot 10^{-3} m$ Thickness: $e=0.006 m$	surface $A=2.10^{-4} m^2$
elements CD and BD	ray: $R=5.683099 \cdot 10^{-3} m$ Thickness: $e=0.005 m$	surface $A=1.10^{-4} m^2$
Poisson's ratio:	$\nu=0.3$	

Limiting conditions:

`DDL_IMPO= (Tout=' OUI', DZ= 0. , DRX= 0. , DRY= 0.)`

To treat the rotary joints, one creates as many nodes as of ends of bar.



- with the nodes A , B and $D4$: `DDL_IMPO=_F (Tout=' OUI', DX= 0. , D4= 0. ,)`
- with the nodes $C1$, $C2$, $C3$ and $D3$, $D4$ continuity of the translations, by `LIAISON_DDL DX` and `DY`.
- no rotation is imposed.

8.2 Characteristics of the grid

Many nodes: 8

Many meshes and types: 4 `SEG2`

Grid of the two hollow sections		
Elements	Grid	Characteristics
AC and BC		240 nodes 79 <code>SEG2</code> 415 <code>TRIA3</code>
CD and BD		127 nodes 56 <code>SEG2</code> 210 <code>TRIA3</code>

8.3 Remarks

In this modeling one calculates the dynamic response complexes system subjected to a complex harmonic excitation ($F = -9810. + 0.j$) in the presence of a viscous damping proportional to rigidity and the mass. ($AMOR_ALPHA = AMOR_BETA = 0.1$). The results are compared with the results got with modeling POU_D_T by taking of account characteristics A , IY and IZ equal to those calculated by integrations on fibres.

8.4 Sizes tested and results

The results (Displacement, Speed and Acceleration) were got at a frequency of 100hz

Not	Displacement (m)	Type of Reference	Reference	% tolerance
D	DX	AUTRE_ASTER	-1.64397E-05-9.09482E-06j	0.10
	DY	AUTRE_ASTER	2.51858E-05+1.78386E-05j	0.10

Not	Speed (m/s)	Type of Reference	Reference	% tolerance
D	DX	AUTRE_ASTER	5.71444E-03-0.0103293j	0.10
	DY	AUTRE_ASTER	-0.011208+0.0158247j	0.10

Not	Acceleration (m/s ²)	Type of Reference	Reference	% tolerance
D	DX	AUTRE_ASTER	6.490118+3.590490j	0.10
	DY	AUTRE_ASTER	-9.942974-7.0424160j	0.10

9 Modeling G

9.1 Characteristics of modeling

4 elements POU_D_TG of circular section: 4 meshes SEG2
 elements *AC* and *BC* ray: $R=7.97884 \cdot 10^{-3} m$ Surface $A=2 \cdot 10^{-4} m^2$
 elements *CD* and *BD* ray: $R=5.683099 \cdot 10^{-3} m$ surface $A=1 \cdot 10^{-4} m^2$
 Thickness: $e=0.005 m$

Limiting conditions:

- DDL_IMPO= (TOUT=' OUI' DZ= 0. , DRX= 0. , DRY= 0.)
- with the nodes *A* , *B* : DDL_IMPO=_F (DX= 0. , DY= 0. ,)

9.2 Characteristics of the grid

Many nodes: 8
 Many meshes and types: 4 SEG2

9.3 Sizes tested and results

Displacements:

Component	Node	Reference	Value
<i>DX</i>	<i>C</i>	ANALYTICAL	2.65170E-04
<i>DY</i>	<i>C</i>	ANALYTICAL	8.83900E-05
<i>DX</i>	<i>D</i>	ANALYTICAL	3.47902E-03
<i>DY</i>	<i>D</i>	ANALYTICAL	-5.60084E-03

Constraints of type beam:

Size	Component	Node	Reference	Value
SIPO_ELNO	SN	<i>A</i>	ANALYTICAL	6.93641E+07
SIPO_ELNO	SN	<i>B</i>	ANALYTICAL	-3.46815E+07
SIPO_ELNO	SN	<i>C</i>	ANALYTICAL	1.55074E+08
SIPO_ELNO	SN	<i>D</i>	ANALYTICAL	-2.08067E+08
SIPM_ELNO	SIXXMAX	<i>A</i>	ANALYTICAL	6.93641E+07
SIPM_ELNO	SIXXMIN	<i>B</i>	ANALYTICAL	-3.80667E+07

10 Summary of the results

The results are in conformity with the reference solution for three modelings:

- model of beams,
- model of beams and linear relations,
- model of bars.

Elements `POU_D_TG`, `POU_D_EM` and `POU_D_TGM` allow to get results very close to those obtained with the elements `POU_D_T`.