SSLL11 - Truss of pinned bars under concentrated loading

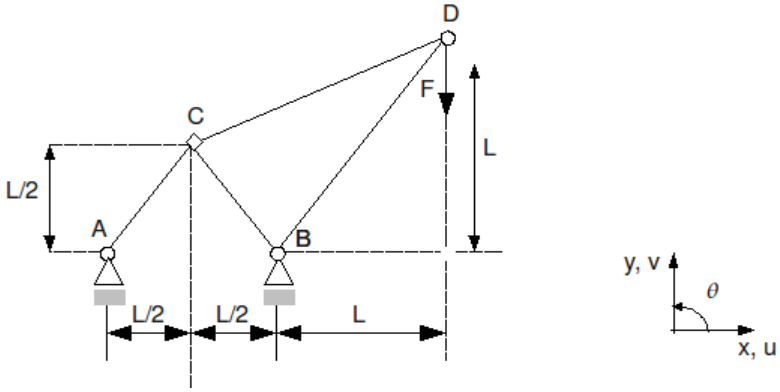
Abstract:
This test makes it possible to check the elements of bar and beam for the structural analysis out of truss. The truss considered is plane. The computation is static, elastic, linear. The reference solution is analytical.

Three modelizations make it possible to test elements POU_D_T with and without rotulées connections, as well as the elements BARS.

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

1 Problem of reference

1.1 Geometry



Length $L=1\,m$

elements AC and BC circular section $A=2.10^{-4}m^2$

elements CD and BD circular section $A=1.10^{-4}m^2$

Coordinated 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

Modulus Young: $E=1.962\,10^{11}\,Pa$

1.3 Boundary conditions and loadings

the nodes A and B are pin-jointed: $u=v=0$

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

2 Reference solution

2.1 Method of calculating used for the reference solution

the reference solution is that given in file SSLL11/89 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 analytical

solution Solution.

2.4 Bibliographical references

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

3 Modelization A

3.1 Characteristic of the modelization

Taking into account slenderness, the taking into account of the pinned ends modifies the results little. For this modelization, the pinned ends in A B, C and D are rigidified (continuity of the 3 components of generalized forces).
4 beams of full circular section: 4 meshes SEG2

elements AC and BC radius $R=7.978845\,10^{-3}\,m$ (area $A=2.10^{-4}\,m^2$)
elements CD and BD radius $R=5.641895\,10^{-3}\,m$ (area $A=1.10^{-4}\,m^2$)
Poisson's ratio: $\nu=0.3$

Limiting conditions:
in all the nodes :

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

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

3.2 Characteristic of the mesh

Many nodes : 4
Number of meshes and types: 4 SEG2

3.3 Quantities tested and Standard

Identification	results of reference	Value	Tolerance
DX to point C	"ANALYTIQUE"	2.65E-04	3.0E-04
DY at point C	"ANALYTIQUE"	0.8839E-04	3.0E-04
DX at point D	"ANALYTIQUE"	3.47902E-03	3.0E-04
DY at point D	"ANALYTIQUE"	- 5.60084E-03	3.0E-04

4 Modelization B

4.1 Characteristic of the modelization

4 elements POU_D_T of full circular section: 4 meshes SEG2

elements AC and BC radius $R=7.978845\,10^{-3}\,m$ (area $A=2.10^{-4}\,m^2$)

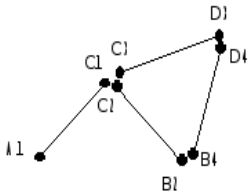
elements CD and BD radius $R=5.641895\,10^{-3}\,m$ (area $A=1.10^{-4}\,m^2$)

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 mesh

Many nodes: 4
Number of meshes and types: 4 SEG2

4.3 Quantities tested and results

Not	Displacement (m)	Standard of Reference	*Reference*	*Tolerance*
C	u_c	ANALYTIQUE	2.6517E-04	3.0E-04
	v_c	ANALYTIQUE	0.8839E-04	3.0E-04
D	u_D	ANALYTIQUE	3.47902E-03	3.0E-04
	v_D	ANALYTIQUE	– 5.60084E-03	3.0E-04

5 Modelization C

5.1 Characteristic of the modelization

4 elements BARS full circular section: 4 meshes SEG2

elements AC and BC radius $R=7.97884510^{-3}m$ (area $A=2.10^{-4}m^2$)

elements CD and BD radius $R=5.64189510^{-3}m$ (area $A=1.10^{-4}m^2$)

Poisson's ratio: $\nu=0.3$

Limiting conditions:

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

5.2 Characteristic of the mesh

Many nodes: 4
Number of meshes and types: 4 SEG2

5.3 Quantities tested and static

Computation results:

Not	Displacement (m)	Standard of Reference	Reference	Tolerance
C	u_c	ANALYTIQUE	2.6517E	-04.1.0E-04
	v_c	ANALYTIQUE	8.84E-05	1.0E-04
D	u_D	ANALYTIQUE	3.47902E-03	1.0E-04
	v_D	ANALYTIQUE	– 5.60084E-03	1.0E-04

Computation harmonic:

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

6 Modelization D

6.1 Characteristic of the modelization

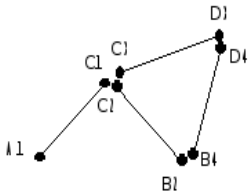
4 elements POU_D_TG of hollow circular section: 4 meshes SEG2

elements AC and BC	radius: $R=8.305164\,10^{-3}m$ Thickness: $e=0.006\,m$	area $A=2.10^{-4}m^2$
elements CD and BD	radius: $R=5.683099\,10^{-3}\,m$ Thickness: $e=0.005\,m$	area $A=1.10^{-4}\,m^2$
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 $A1$, $B2$ 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 mesh

Many nodes: 8
Number of meshes and types: 4 SEG2

6.3 Remarks

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

6.4 Quantities tested and results

the results (Displacement, Velocity and Acceleration) were got with a frequency of $100\,Hz$

Point	Displacement (m)	Standard of Reference	Reference	Non regression
D	DX	Tolerance	-1.65073E-05-9.22424E-06j	1.00E-003
	DY	Non regression	2.52829E-05+1.80184E-05j	1.00E-003

Not	Velocity (m/s)	Standard of Reference	Reference	Non regression
D	DX	Tolerance	5.79576E-03-1.03719E-02j	1.00E-003
	DY	Non regression	-1.13213E-02+1.58857E-02j	1.00E-003

Not	Acceleration (m/s^2)	Standard of Reference	Reference	Non regression
D	DX	Tolerance	6.51684+3.64158j	1.00E-003
	DY	Non regression	-9.98130-7.11336j	1.00E-003

7 Modelization E

7.1 Characteristic of the modelization

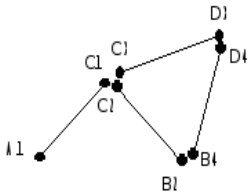
4 elements POU_D_EM of hollow circular section: 4 meshes SEG2

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

Limiting conditions:

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

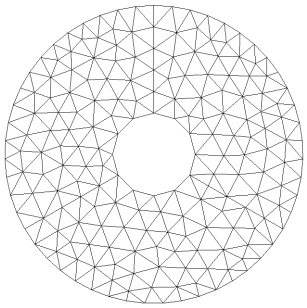
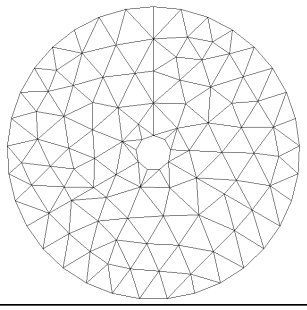
To treat the rotary joints, one creates as many nodes as of ends of bar.



- 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 mesh

Many nodes: 8
Number of meshes and types: 4 SEG2

Mesh of the two hollow sections		
Elements	Mesh	Characteristics
AC and BC		240 nodes 79 SEG2 415 TRIA3
CD and BD		127 nodes 56 SEG2 210 TRIA3

7.3 Remarks

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

7.4 Quantities tested and results

the results (Displacement, Velocity and Acceleration) were got with a frequency of $100\,Hz$

Point	Displacement (m)	Standard 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	3.0

Point	Velocity (m/s)	Standard 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%

Point	Acceleration (m/s^2)	Standard of Reference	Reference	Tolerance
D	DX	AUTRE_ASTER	6.51684+3.64158j	3.50%
	DY	AUTRE_ASTER	-9.98130-7.11336j	3.00%

8 Modelization F

8.1 Characteristic of the modelization

4 elements POU_D_TGM of hollow circular section: 4 meshes SEG2

elements AC and BC and radius: $R=8.305164\,10^{-3}\,m$ area $A=2.\,10^{-4}\,m^2$
Thickness: $e=0.006\,m$

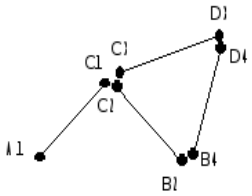
elements CD and BD and radius: $R=5.683099\,10^{-3}\,m$ area $A=1.\,10^{-4}\,m^2$
Thickness: $e=0.005\,m$

Poisson's ratio: $\nu=0.3$

Limiting conditions:

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

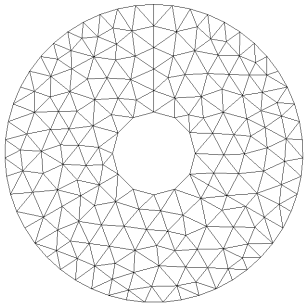
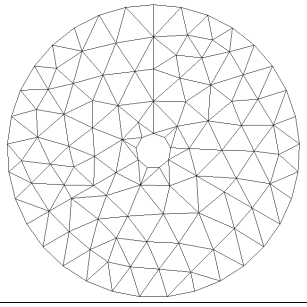
To treat the rotary joints, one creates as many nodes as of ends of bar.



- 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 mesh

Many nodes: 8
Number of meshes and types: 4 SEG2

Mesh of the two hollow sections		
Elements	Mesh	Characteristics
AC and BC		240 nodes 79 SEG2 415 TRIA3
CD and BD		127 nodes 56 SEG2 210 TRIA3

8.3 Remarks

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

8.4 Quantities tested and results

the results (Displacement, Velocity and Acceleration) were got with a frequency of $100\mathrm{hz}$

Point	Displacement (m)	Standard 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

Point	Velocity (m/s)	Standard of Reference	Reference	% tolerance
D	DX	AUTRE_ASTER	5.71444E-03-0.0103293j	0.10
	DY	AUTRE_ASTER	-0.011208+0.0158247j	0.10

Point	Acceleration (m/s^2)	Standard of Reference	Reference	% tolerance
D	DX	AUTRE_ASTER	6.490118+3.590490j	0.10
	DY	AUTRE_ASTER	-9.942974-7.0424160j	0.10

9 Modelization G

9.1 Characteristic of the modelization

4 elements POU_D_TG of circular section: 4 meshes SEG2

elements AC and BC radius: $R=7.97884\,10^{-3}\,m$ Area $A=2.10^{-4}\,m^2$

elements CD and BD radius: $R=5.683099\,10^{-3}\,m$ area $A=1.10^{-4}\,m^2$

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 Characteristic of the mesh

Many nodes: 8
Number of meshes and types: 4 SEG2

9.3 Quantities tested and Displacements

results:

Component	Node	Reference	Value
DX	C	ANALYTIQUE	2.65170E−04
DY	C	ANALYTIQUE	8.83900E−05
DX	D	ANALYTIQUE	3.47902E−03
DY	D	ANALYTIQUE	−5.60084E−03

Forced of type beam:

Component	quantity	Node	Reference	Value
SIPO_ELNO	SN	A	ANALYTIQUE	6.93641E+07
SIPO_ELNO	SN	B	ANALYTIQUE	−3.46815E+07
SIPO_ELNO	SN	C	ANALYTIQUE	1.55074E+08
SIPO_ELNO	SN	D	ANALYTIQUE	−2.08067E+08
SIPM_ELNO	SIXX	A	ANALYTIQUE	6.93641E+07
SIPM_ELNO	SIXY	A	ANALYTIQUE	3.41702E+03
SIPM_ELNO	SIXX	B	ANALYTIQUE	−3.80667E+07
SIPM_ELNO	SIXY	B	ANALYTIQUE	1.56495E+04

10 Summary of the results

the results are in conformity with the reference solution for the three modelizations:

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

Elements POU_D_TG, POU_D_EM and POU_D_TGM make it possible to get results very close to those obtained with elements POU_D_T.