SSLS27 - Twisted or bent thin plate

Summarized:

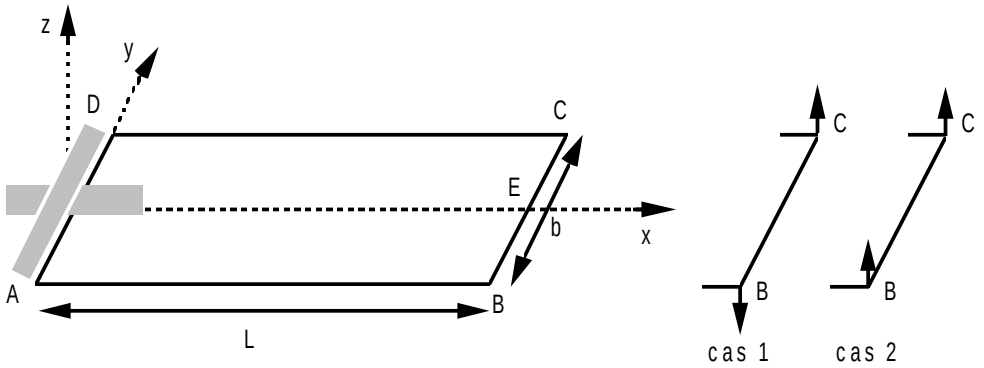
The test, taken again guide VPCS, makes it possible to check the behavior of a clamped plane plate subjected at its loose lead with two nodal forces of the same sign (bending) or of opposite sign (torsion).

The first loading constitutes an extension of the initial test for which a reference solution is given in [bib3].

5 modelizations are carried out: DKT, DST, DKQ, DSQ and Q4G.

1 Problem of reference

1.1 Geometry



Longueur	L = 12 m
Largeur	b = 1 m
Epaisseur	t = 0.05 m

Coordinated of the points (in m):

	A	B	C	D	E
x	0.	12.	12.	0.	12.
y	– 0.5	– 0.5	0.5.0.5		0.
z	0.	0.	0.	0.	0.

1.2 Properties of the material

the elastic properties of the material considered are the following ones:
Young modulus: $E=1.10^{11}Pa$
Poisson's ratio: $\nu=0.25$

1.3 Boundary conditions and loadings

clamped AD Side:
any point P such as $x_P=0$ ($u=v=w=0$ $\theta_x=\theta_y=\theta_z=0$)

Loading: 2 loading cases

1) in B and C : opposite forces parallel with the axis Z $F_{z_B}=-1N$ $F_{z_C}=+1N$
2) in B and C : of the same forces meanings parallel with the axis Z $F_{z_B}=+1N$ $F_{z_C}=+1N$

2 Reference solution

2.1 Method of calculating used for the reference solution

- opposite Forces perpendicular to the plate [bib1], [bib2]

  the reference solution is that given in file SSLS27/89 of guide VPCS:
  Displacement of point: C $w=35.37\,10^{-7}m$

  Resultant of the forces to the fixed support (AD) according to DZ : $RESULT_Z=0$
  Moment associated with the resultant with the forces to the fixed support in the middle of AD :
  $MOMENT_X=-1$
  $MOMENT_Y=0$

- Of the same forces meanings perpendicular to the plate [bib3]

  the formulation out of beam of Eulerian give a solution approached for a different ν Poisson's ratio.

  Displacement of all the nodes on the side BC : $w=\frac{F}{6EI_z}2\ L^3$

  Resultant of the forces to the fixed support (AD) according to DZ : $RESULT_Z=-2$
  Moment associated with the resultant with the forces to the fixed support in the middle of AD :
  $MOMENT_X=0$
  $MOMENT_Y=24$

2.2 Results of reference

Displacement of the points B , C and E . Resultant at the fixed support along AD , time with the fixed support compared to the axes X and Y in the middle of AD .

2.3 Uncertainty on the analytical

solution Solution.

2.4 Bibliographical references

1) J. ROBINSON “Element evaluating. A set of assessment shares and standard tests” Proceedings of Finite Methods Element in the commercial Environment, vol. 1, (October 1978).

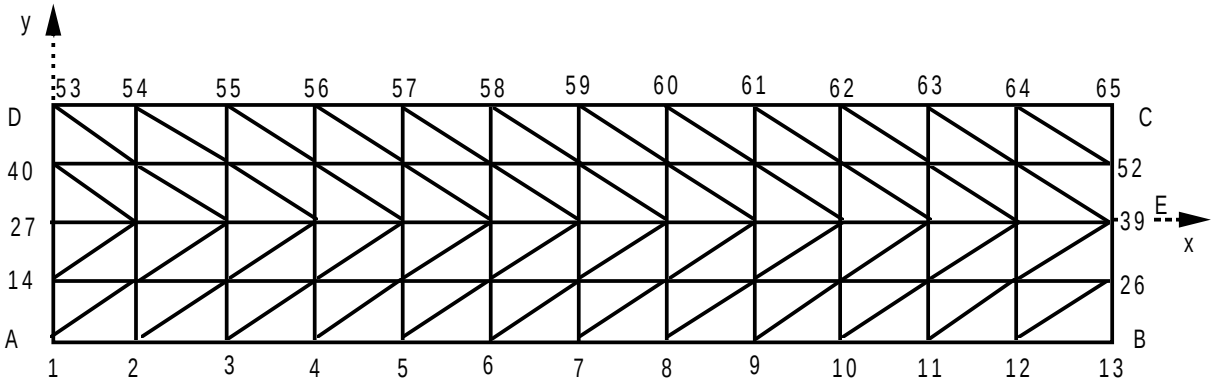
2) J.L. BATOZ, M.B. Quadrilateral TAHAR “Evaluating of new thin punt boundary element” International Newspaper for Numerical Methods in Engineering, vol. 18, John Wiley & Sounds (1982).

3) R.J. ROARK, W.C. YOUNG “Formulated for Stress and Strain” New York: Mc Graw - Hill, 5° edition, p 96.

3 Modelization A

3.1 Characteristic of the modelization

Shell element DKT



Cutting:	12 in length	4 in width:	96 meshes TRIA3 with symmetry compared axis Ox
longitudinal	transverse	$b/4t=5$	
	Slenderness	$L/12t=20$	

2 opposite

1) Forces loading cases
2) of the same Forces meaning

Name of the nodes:

Not $A=N1$ Not $C=N65$ Not $E=N39$
Not $B=N13$ Not $D=N53$

3.2 Characteristic of the mesh

Many nodes: 65
Number of meshes and types: 96 TRIA3

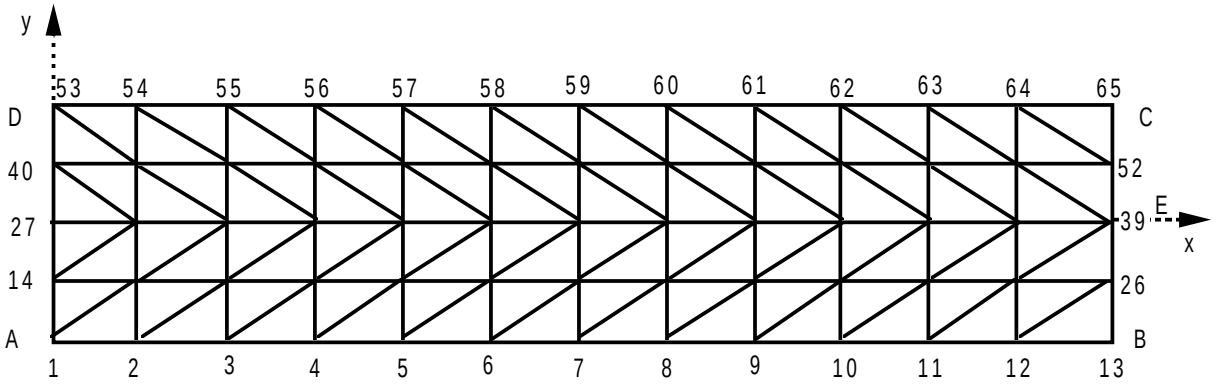
3.3 Quantities tested and Loading case

results	Not	Quantity and Standard	unit	Reference of reference	Tolerance
1	B	displacement $DZ(m)$	– 3.537 10-6	"ANALYTIQUE"	0.5%
	E	displacement $DZ(m)$	0	"ANALYTIQUE"	1.0E-12
	C	displacement $DZ(m)$	3.537 10-6	"ANALYTIQUE"	0.5%
2	B	displacement $DZ(m)$	1.1059 10-3	"ANALYTIQUE"	1%
	E	displacement $DZ(m)$	1.1059 10-3	"ANALYTIQUE"	1%
	C	displacement $DZ(m)$	1.1059 10-3	"ANALYTIQUE"	1%

4 Modelization B

4.1 Characteristic of the modelization

Shell element DST



Cutting:	12 in length	4 in width:	96 meshes TRIA3 with symmetry compared axis Ox
longitudinal	transverse	$b/4t=5$	
	Slenderness	$L/12t=20$	

2 opposite

1) Forces loading cases
2) of the same Forces meaning

Name of the nodes:

Not $A=N1$	Not $C=N65$	Not $E=N39$
Not $B=N13$	Not $D=N53$	Not $F=N27$

4.2 Characteristic of the mesh

Many nodes: 65
Number of meshes and types: 96 TRIA3

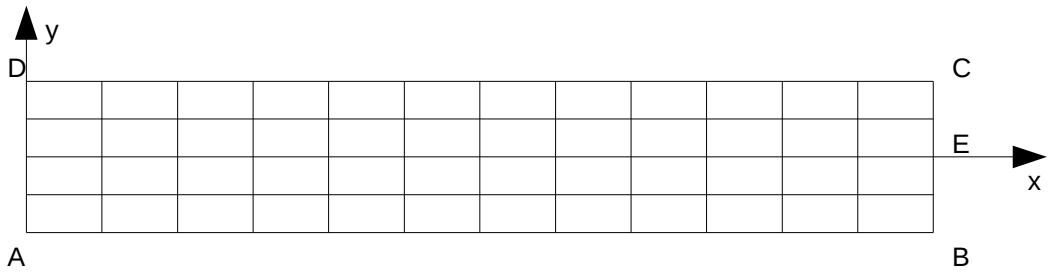
4.3 Quantities tested and Loading case

results	Not	Quantity and Standard	unit	Reference of reference	Tolerance
1	B	displacement $DZ(m)$	– 3.537 10-6	"ANALYTIQUE"	0.5%
	E	displacement $DZ(m)$	0	"ANALYTIQUE"	1.0E-12
	C	displacement $DZ(m)$	3.537 10-6	"ANALYTIQUE"	0.5%
	AD	Resultant force $DZ(N)$	0	"ANALYTIQUE"	1.0E-8
	F	Moment $DRX(N.m)$	-1	"ANALYTIQUE"	1.0E-6%
	F	Moment $DRY(N.m)$	0	"ANALYTIQUE"	1.0E-8
2	B	displacement $DZ(m)$	1.1059 10-3	"ANALYTIQUE"	1%
	E	displacement $DZ(m)$	1.1059 10-3	"ANALYTIQUE"	1%
	C	displacement $DZ(m)$	1.1059 10-3	"ANALYTIQUE"	1%
	AD	Resultant force $DZ(N)$	-2	"ANALYTIQUE"	1.0E-6%
	F	Moment $DRX(N.m)$	0	"ANALYTIQUE"	1.0E-8
	F	Moment $DRY(N.m)$	24	"ANALYTIQUE"	1.0E-6%

5 Modelization C

5.1 Characteristic of the modelization

Shell element DKT



Cutting:	12 in length	4 in width:	48 meshes QUAD4 with symmetry compared axis Ox
transverse	Slenderness	$b/4t=5$	
longitudinal		$L/12t=20$	

2 opposite

1) Forces loading cases
2) of the same Forces meanings

5.2 Characteristic of the mesh

Many nodes: 65
Number of meshes and types: 48 QUAD4

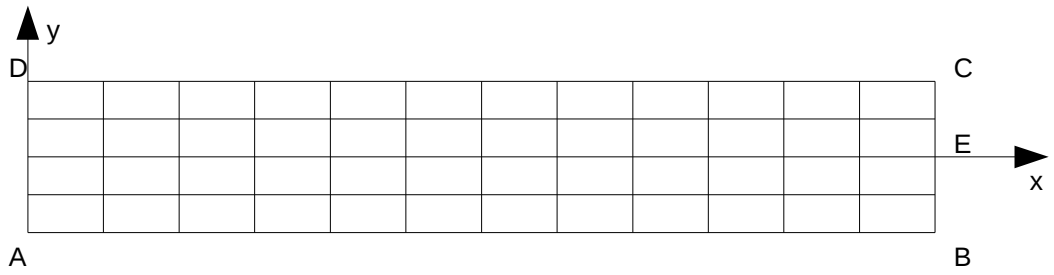
5.3 Quantities tested and Loading case

results	Not	Quantity and Standard	unit	Reference of reference	Tolerance
1	B	displacement $DZ(m)$	– 3.537 10-6	"ANALYTIQUE"	0.5%
	E	displacement $DZ(m)$	0	"ANALYTIQUE"	1.0E-12
	C	displacement $DZ(m)$	3.537 10-6	"ANALYTIQUE"	0.5%
2	B	displacement $DZ(m)$	1.1059 10-3	"ANALYTIQUE"	1%
	E	displacement $DZ(m)$	1.1059 10-3	"ANALYTIQUE"	1%
	C	displacement $DZ(m)$	1.1059 10-3	"ANALYTIQUE"	1%

6 Modelization D

6.1 Characteristic of the modelization

Shell element DST



Cutting:	12 in length	4 in width:	48 meshes QUAD4 with symmetry compared axis Ox
transverse	Slenderness	$b/4t=5$	
	longitudinal	$L/12t=20$	

2 loading cases

1) Opposite forces
2) Of the same forces meanings

6.2 Characteristic of the mesh

Many nodes: 65
Number of meshes and types: 48 QUAD4

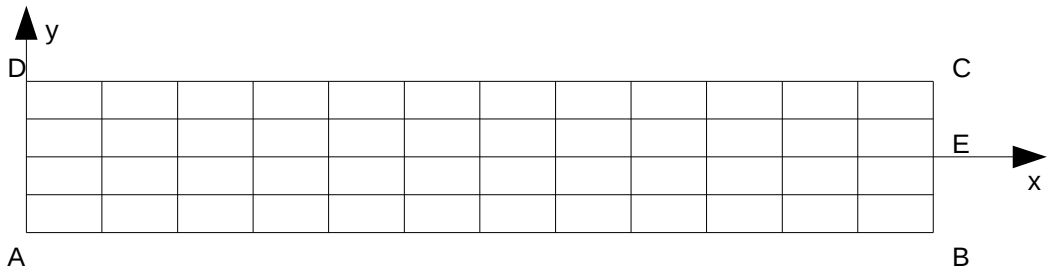
6.3 Quantities tested and Loading case

results	Not	Quantity and Standard	unit	Reference of reference	Tolerance
1	B	displacement $DZ(m)$	– 3.537 10-6	"ANALYTIQUE"	0.5%
	E	displacement $DZ(m)$	0	"ANALYTIQUE"	1.0E-12
	C	displacement $DZ(m)$	3.537 10-6	"ANALYTIQUE"	0.5%
2	B	displacement $DZ(m)$	1.1059 10-3	"ANALYTIQUE"	1%
	E	displacement $DZ(m)$	1.1059 10-3	"ANALYTIQUE"	1%
	C	displacement $DZ(m)$	1.1059 10-3	"ANALYTIQUE"	1%

7 Modelization E

7.1 Characteristic of the modelization

Shell element Q4G



Cutting:	12 in length	4 in width:	48 meshes QUAD4 with symmetry compared axis Ox
transverse	Slenderness	$b/4t=5$	
	longitudinal	$L/12t=20$	

2 opposite

1)Forces loading cases
2)of the same Forces meanings

7.2 Characteristic of the mesh

Many nodes: 65
Number of meshes and types: 48 QUAD4

7.3 Quantities tested and Loading case

results	Not	Quantity and Standard	unit	Reference of reference	Tolerance
1	B	displacement $DZ(m)$	– 3.537 10-6	"ANALYTIQUE"	0.5%
	E	displacement $DZ(m)$	0	"ANALYTIQUE"	1.0E-12
	C	displacement $DZ(m)$	3.537 10-6	"ANALYTIQUE"	0.5%
2	B	displacement $DZ(m)$	1.1059 10-3	"ANALYTIQUE"	1%
	E	displacement $DZ(m)$	1.1059 10-3	"ANALYTIQUE"	1%
	C	displacement $DZ(m)$	1.1059 10-3	"ANALYTIQUE"	1%

8 Summary of the results

One finds the analytical results with a very good agreement which the modelization takes account of the transverse shears or not.