SSLS27 - Bored or bent thin section

Summary:

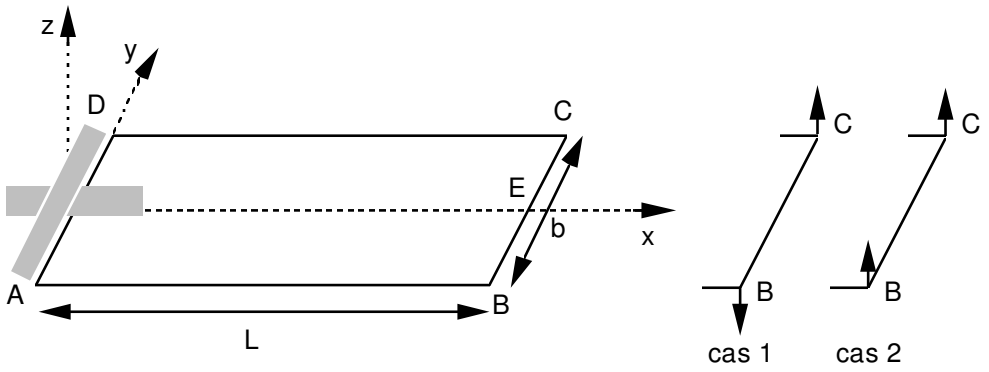
The test, taken again guide VPCS, makes it possible to check the behavior of an embedded plane plate subjected at its loose lead with two nodal forces of the same sign (inflection) or of opposite sign (torsion).

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

5 modelings 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

Coordinates 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 material

The elastic properties of 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

Side AD embedded:
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 $F_{z_B}=-1\,N$ $F_{z_C}=+1\,N$
2) in B and C : of the same forces directions parallel with the axis Z $F_{z_B}=+1\,N$ $F_{z_C}=+1\,N$

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 card SSLS27/89 of guide VPCS:
  Displacement of the point C : $w=35.37\,10^{-7}\,m$

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

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

  The formulation in beam of Euler gives a solution approached for a Poisson's ratio ν different.

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

  Resultant of the efforts to embedding (AD) according to DZ : $RESULT_Z=-2$
  Moment associated with the resultant with the efforts to embedding 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 with embedding along AD , moment with embedding compared to the axes X and Y in the middle of AD .

2.3 Uncertainty on the solution

Analytical solution.

2.4 Bibliographical references

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

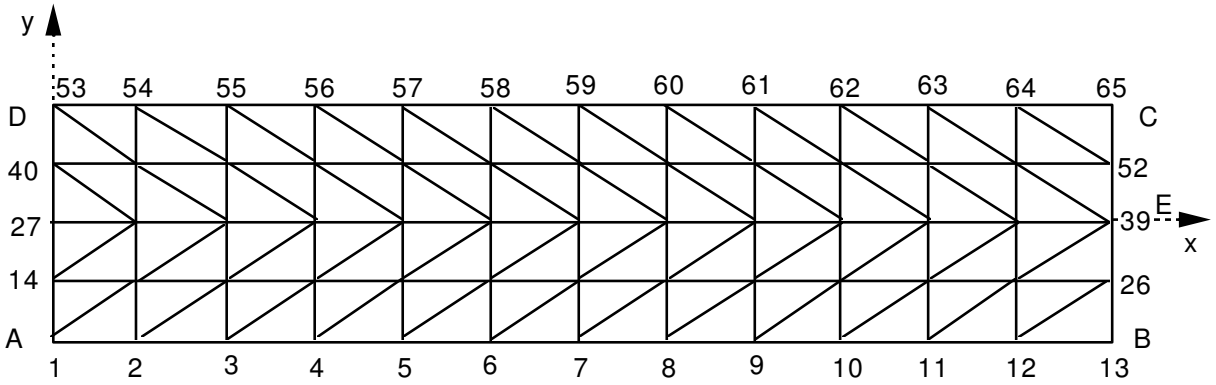
2) J.L. BATOZ, M.B. Quadrilateral TAHAR “Evaluation of new thin punt boundary element” International Newspaper for Numerical Methods in Engineering, vol. 18, John Wiley & Sounds (1982).

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

3 Modeling A

3.1 Characteristics of modeling

Element of hull DKT



Cutting:	12 in length	4 in width:	96 meshs TRIA3 with symmetry by report centers Ox
Twinge	transverse	$b/4t=5$	
	longitudinal	$L/12t=20$	

2 loading cases

1) Opposite forces
2) Of the same forces direction

Name of the nodes:

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

3.2 Characteristics of the grid

Many nodes: 65
Many meshs and types: 96 TRIA3

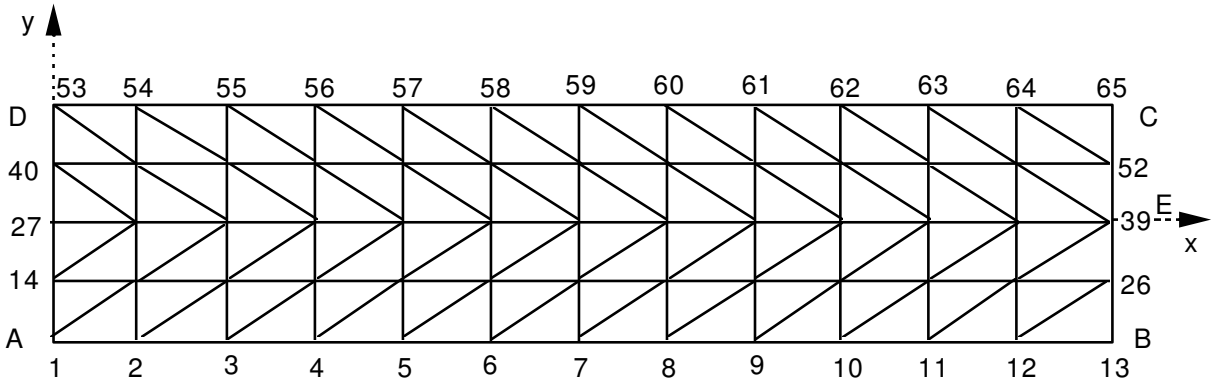
3.3 Sizes tested and results

Loading case	Not	Size and unit	Reference	Type of reference	Tolerance
1	B	displacement $DZ(m)$	– 3,537 10^{-6}	'ANALYTICAL'	0.5%
	E	displacement $DZ(m)$	0	'ANALYTICAL'	1.0E-12
	C	displacement $DZ(m)$	3,537 10^{-6}	'ANALYTICAL'	0.5%
2	B	displacement $DZ(m)$	1.1059 10^{-3}	'ANALYTICAL'	1%
	E	displacement $DZ(m)$	1.1059 10^{-3}	'ANALYTICAL'	1%
	C	displacement $DZ(m)$	1.1059 10^{-3}	'ANALYTICAL'	1%

4 Modeling B

4.1 Characteristics of modeling

Element of hull DST



Cutting:	12 in length	4 in width:	96 meshs TRIA3 with symmetry by report centers Ox
Twinge	transverse	$b/4t=5$	
	longitudinal	$L/12t=20$	

2 loading cases

1) Opposite forces
2) Of the same forces direction

Name of the nodes:

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

4.2 Characteristics of the grid

Many nodes: 65
Many meshs and types: 96 TRIA3

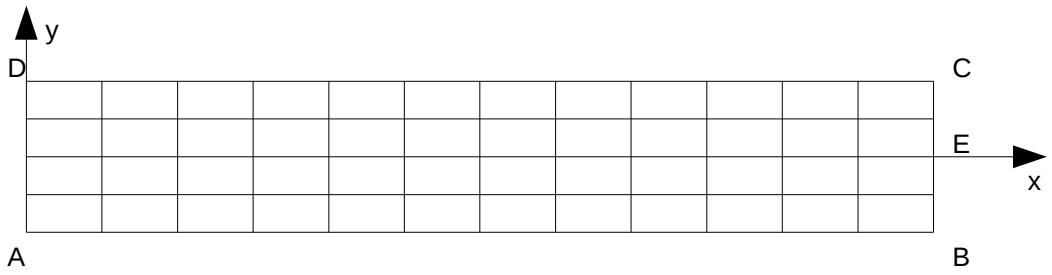
4.3 Sizes tested and results

Loading case	Not	Size and unit	Reference	Type of reference	Tolerance
1	B	displacement $DZ(m)$	– 3,537 10^{-6}	'ANALYTICAL'	0.5%
	E	displacement $DZ(m)$	0	'ANALYTICAL'	1.0E-12
	C	displacement $DZ(m)$	3,537 10^{-6}	'ANALYTICAL'	0.5%
	AD	Resulting force $DZ(N)$	0	'ANALYTICAL'	1.0E-8
	F	Moment $DRX(N.m)$	-1	'ANALYTICAL'	1.0E-6%
	F	Moment $DRY(N.m)$	0	'ANALYTICAL'	1.0E-8
2	B	displacement $DZ(m)$	1.1059 10^{-3}	'ANALYTICAL'	1%
	E	displacement $DZ(m)$	1.1059 10^{-3}	'ANALYTICAL'	1%
	C	displacement $DZ(m)$	1.1059 10^{-3}	'ANALYTICAL'	1%
	AD	Resulting force $DZ(N)$	-2	'ANALYTICAL'	1.0E-6%
	F	Moment $DRX(N.m)$	0	'ANALYTICAL'	1.0E-8
	F	Moment $DRY(N.m)$	24	'ANALYTICAL'	1.0E-6%

5 Modeling C

5.1 Characteristics of modeling

Element of hull DKT



Cutting:	12 in length	4 in width:	48 meshs QUAD4 with symmetry by report centers Ox
Twinge	transverse	$b/4t=5$	
	longitudinal	$L/12t=20$	

2 loading cases

1) Opposite forces
2) Of the same forces direction

5.2 Characteristics of the grid

Many nodes: 65
Many meshs and types: 48 QUAD4

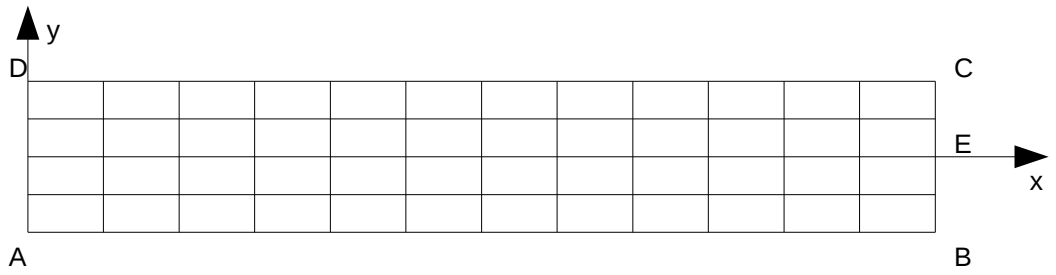
5.3 Sizes tested and results

Loading case	Not	Size and unit	Reference	Type of reference	Tolerance
1	B	displacement $DZ(m)$	– 3,537 10^{-6}	'ANALYTICAL'	0.5%
	E	displacement $DZ(m)$	0	'ANALYTICAL'	1.0E-12
	C	displacement $DZ(m)$	3,537 10^{-6}	'ANALYTICAL'	0.5%
2	B	displacement $DZ(m)$	1.1059 10^{-3}	'ANALYTICAL'	1%
	E	displacement $DZ(m)$	1.1059 10^{-3}	'ANALYTICAL'	1%
	C	displacement $DZ(m)$	1.1059 10^{-3}	'ANALYTICAL'	1%

6 Modeling D

6.1 Characteristics of modeling

Element of hull DST



Cutting:	12 in length	4 in width:	48 meshs QUAD4 with symmetry by report centers Ox
Twinge	transverse	$b/4t=5$	
	longitudinal	$L/12t=20$	

2 loading cases

1) Opposite forces
2) Of the same forces direction

6.2 Characteristics of the grid

Many nodes: 65
Many meshs and types: 48 QUAD4

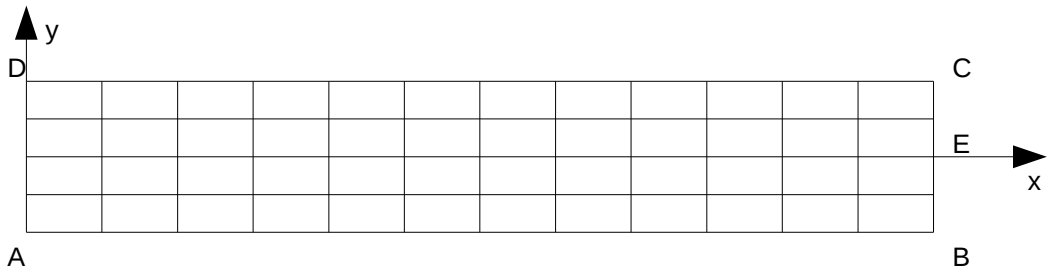
6.3 Sizes tested and results

Loading case	Not	Size and unit	Reference	Type of reference	Tolerance
1	B	displacement $DZ(m)$	– 3,537 10^{-6}	'ANALYTICAL'	0.5%
	E	displacement $DZ(m)$	0	'ANALYTICAL'	1.0E-12
	C	displacement $DZ(m)$	3,537 10^{-6}	'ANALYTICAL'	0.5%
2	B	displacement $DZ(m)$	1.1059 10^{-3}	'ANALYTICAL'	1%
	E	displacement $DZ(m)$	1.1059 10^{-3}	'ANALYTICAL'	1%
	C	displacement $DZ(m)$	1.1059 10^{-3}	'ANALYTICAL'	1%

7 Modeling E

7.1 Characteristics of modeling

Element of hull Q4G



Cutting:	12 in length	4 in width:	48 meshs QUAD4 with symmetry by report centers Ox
Twinge	transverse	$b/4t=5$	
	longitudinal	$L/12t=20$	

2 loading cases

1) Opposite forces
2) Of the same forces direction

7.2 Characteristics of the grid

Many nodes: 65
Many meshs and types: 48 QUAD4

7.3 Sizes tested and results

Loading case	Not	Size and unit	Reference	Type of reference	Tolerance
1	B	displacement $DZ(m)$	– 3,537 10^{-6}	'ANALYTICAL'	0.5%
	E	displacement $DZ(m)$	0	'ANALYTICAL'	1.0E-12
	C	displacement $DZ(m)$	3,537 10^{-6}	'ANALYTICAL'	0.5%
2	B	displacement $DZ(m)$	1.1059 10^{-3}	'ANALYTICAL'	1%
	E	displacement $DZ(m)$	1.1059 10^{-3}	'ANALYTICAL'	1%
	C	displacement $DZ(m)$	1.1059 10^{-3}	'ANALYTICAL'	1%

8 Summary of the results

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