TPLS102 – Thick beam in plane constraints – linear temperature variation according to the width

Summary:

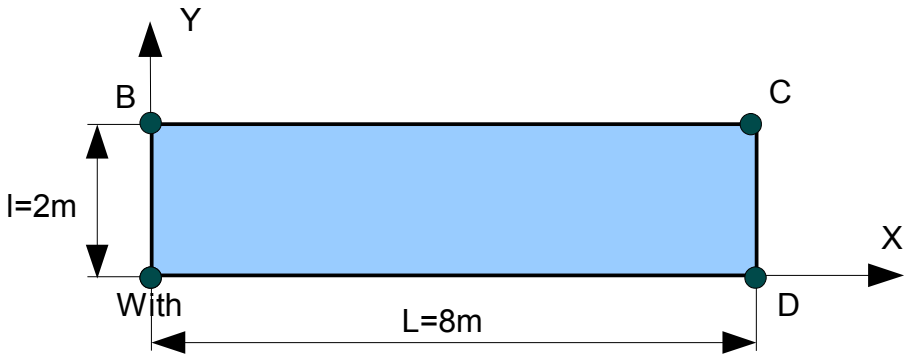
The objective of this test is to validate the calculation of the constraints in a subjected thick beam in plane constraints has a variation in the temperature according to the width.

Modelings :

- Modeling A : DKT with meshs TRIA3
- Modeling B : DKT with meshs QUAD4

1 Problem of reference

1.1 Geometry



Thickness = $0.1\mathrm{m}$.

1.2 Properties of material

The material is elastic isotropic whose properties are:

- $E=20\,000\,Pa$
- $\nu=0.3$
- $\alpha=10^{-5}/°C$

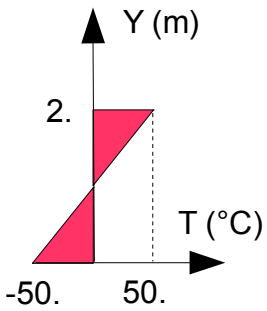
1.3 Boundary conditions and loadings

Boundary conditions:

- On the edges AB and CD : $DX=DZ=0$
- On the edge BC : $DY=0$

Loading

- The loading applied is a loading of temperature
  - Constant according to X and Z
  - Variable along the axis Y : $T(Y)=50\mathrm{Y}-50$



1.4 Initial conditions

Nothing

2 Reference solution

2.1 Method of calculating

The reference solution for the calculation of the constraints in the beam is given in [1], [2].

2.2 Sizes and results of reference

Constraints σ_{xx}, σ_{yy} and σ_{xy} along the axis Y.

$\sigma_{xx}(Y)=-10Y+10$

$\sigma_{yy}(Y)=0.$

$\sigma_{xy}(Y)=0.$

$Y(m)$	σ_{xx}	σ_{yy}	σ_{xy}
0.0	$10.0\,Pa$	$0.0\,Pa$	$0.0\,Pa$
0.5	$5.0\,Pa$	$0.0\,Pa$	$0.0\,Pa$
1.0	$0.0\,Pa$	$0.0\,Pa$	$0.0\,Pa$
1.5	$-5.0\,Pa$	$0.0\,Pa$	$0.0\,Pa$
2.0	$-10.0\,Pa$	$0.0\,Pa$	$0.0\,Pa$

2.3 Uncertainties on the solution

Analytical solution

2.4 Bibliographical references

[1] M.H. SADR-LAHIDJANI: “Modeling and analyzes plates and subjected elastic thin hulls has fields of temperature”, Doctorate UTC, 1984.

[2] J. PITER, HARTEL H. “Improved thermal stress under evaluation load for simple finite element”, I.J.N.M.E, vol. 15,1507-1515, 1980.

3 Modeling A

3.1 Characteristics of modeling

A modeling is used DKT with 3 layers in the thickness.

3.2 Characteristics of the grid

The grid contains 2048 elements of the type TRIA3.

3.3 Sizes tested and results

One tests the constraints on the lower, average and higher skin in two layers.

- Lay down n°1: $-0.05\text{m} < Z < -0.0167\,m$

Identification			Type of reference	Value of reference	Tolerance
INF	$X=0.0\text{m}$ $Y=0.0\text{m}$ $Z=-0.05\text{m}$	*SIXX*	'ANALYTICAL'	10.	2.0%
		SIYY	'ANALYTICAL'	0.	0.6
		SIXY	'ANALYTICAL'	0.	0.05
MOY	$X=0.0\text{m}$ $Y=1.0\text{m}$ $Z=-0.0333\text{m}$	*SIXX*	'ANALYTICAL'	0.	0.05
		SIYY	'ANALYTICAL'	0.	0.2
		SIXY	'ANALYTICAL'	0.	0.0035
SUP	$X=0.0\text{m}$ $Y=2.0\text{m}$ $Z=-0.0167\text{m}$	*SIXX*	'ANALYTICAL'	−10.	1.5%
		SIYY	'ANALYTICAL'	0.	0.5
		SIXY	'ANALYTICAL'	0.	10^{-6}

- Lay down n°3: $0.0167\text{m} < Z < 0.05\text{m}$

Identification			Type of reference	Value of reference	Tolerance
INF	$X = 4.0\text{m}$ $Y = 0.0\text{m}$ $Z = 0.0167\text{m}$	*SIXX*	'ANALYTICAL'	10.	1.5%
		SIYY	'ANALYTICAL'	0.	0.5
		SIXY	'ANALYTICAL'	0.	10^{-4}
MOY	$X = 4.0\text{m}$ $Y = 1.0\text{m}$ $Z = 0.0333\text{m}$	*SIXX*	'ANALYTICAL'	0.	10^{-4}
		SIYY	'ANALYTICAL'	0.	10^{-4}
		SIXY	'ANALYTICAL'	0.	10^{-3}
SUP	$X = 4.0\text{m}$ $Y = 2.0\text{m}$ $Z = 0.05\text{m}$	*SIXX*	'ANALYTICAL'	$-10.$	1.5%
		SIYY	'ANALYTICAL'	0.	0.5
		SIXY	'ANALYTICAL'	0.	10^{-4}

4 Modeling B

4.1 Characteristics of modeling

A modeling is used DKT with 5 layers in the thickness

4.2 Characteristics of the grid

The grid contains 1024 elements of the type QUAD4.

4.3 Sizes tested and results

One tests the constraints on the lower, average and higher skin in two layers.

- Lay down n°2: $-0.03\text{m} < Z < -0.01\text{m}$

Identification			Type of reference	Value of reference	Tolerance
INF	$X=0.0\text{m}$ $Y=0.0\text{m}$ $Z=-0.03\text{m}$	*SIXX*	'ANALYTICAL'	10.	1.5%
		SIYY	'ANALYTICAL'	0.	0.5
		SIXY	'ANALYTICAL'	0.	10^{-6}
MOY	$X=0.0\text{m}$ $Y=1.0\text{m}$ $Z=-0.04\text{m}$	*SIXX*	'ANALYTICAL'	0.	10^{-6}
		SIYY	'ANALYTICAL'	0.	10^{-6}
		SIXY	'ANALYTICAL'	0.	10^{-6}
SUP	$X=0.0\text{m}$ $Y=2.0\text{m}$ $Z=-0.01\text{m}$	*SIXX*	'ANALYTICAL'	$-10.$	1.5%
		SIYY	'ANALYTICAL'	0.	0.5
		SIXY	'ANALYTICAL'	0.	10^{-6}

- Lay down n°5: $0.03\text{m} < Z < 0.05\text{m}$

Identification			Type of reference	Value of reference	Tolerance
INF	$X = 4.0\text{m}$ $Y = 0.0\text{m}$ $Z = 0.03\text{m}$	*SIXX*	'ANALYTICAL'	10.	1.5%
		SIYY	'ANALYTICAL'	0.	0.5
		SIXY	'ANALYTICAL'	0.	10^{-6}
MOY	$X = 4.0\text{m}$ $Y = 1.0\text{m}$ $Z = 0.04\text{m}$	*SIXX*	'ANALYTICAL'	0.	10^{-6}
		SIYY	'ANALYTICAL'	0.	10^{-6}
		SIXY	'ANALYTICAL'	0.	10^{-6}
SUP	$X = 4.0\text{m}$ $Y = 2.0\text{m}$ $Z = 0.05\text{m}$	*SIXX*	'ANALYTICAL'	$-10.$	1.5%
		SIYY	'ANALYTICAL'	0.	0.5
		SIXY	'ANALYTICAL'	0.	10^{-6}

5 Summary of the results

One notes for the constraint σ_{xx} a maximum change of:

- 2.0% with meshs TRIA3
- 1.5% with meshs QUAD4.

A finer grid in the direction of the variation in the temperature would make it possible to get better results.