SSLS138 – Request of a membrane

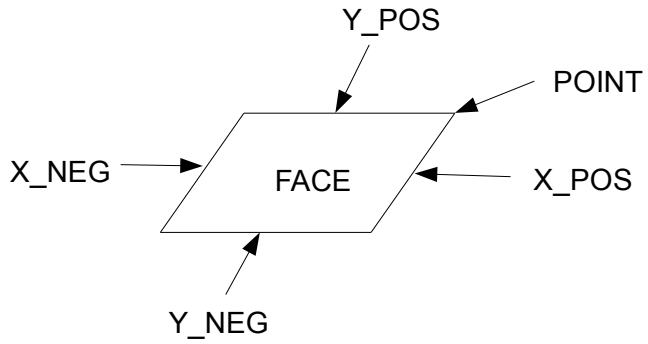
Summarized:

The purpose of this test is to validate the behavior of an anisotropic elastic membrane for several modes of request, as well as the computation of the strains and the stresses in the membrane. One validates all the elements of membrane available.

1 Problem of reference

1.1 Geometry

One considers a square of $1\,m$ on side, represented below:



1.2 Properties of the material

the square presents an anisotropic behavior of membrane, characterized by the following coefficients (the coefficients not mentioned are null):

$$\begin{cases} M_{LLLL}=3 \\ M_{TTTT}=3 \\ M_{LLTT}=1 \\ M_{LTLT}=2 \end{cases}$$

These coefficients are defined in a turned reference of 90° around the axis (Oz).

1.3 Boundary conditions and loadings

One carries out two computations, corresponding to a request of tension and a request of shears of the membrane. The conditions limits corresponding are indicated below:

•Request of tension

$$\begin{cases} u_Z=0 \ \text{ sur } \ \text{FACE} \\ u_X=0 \ \text{ sur } \ \text{X\_NEG} \\ u_Y=0 \ \text{ sur } \ \text{Y\_NEG} \\ F_X=1 \ \text{ sur } \ \text{X\_POS} \end{cases}$$

•Request of shears

$$\begin{cases} u_Z = 0 \text{ sur FACE} \\ u_Y = 0 \text{ sur X\_NEG} \\ u_X = 0 \text{ sur Y\_NEG} \\ u_X = u_Y \text{ sur POINT} \\ F_Y = 1 \text{ sur X\_POS} \\ F_X = 1 \text{ sur Y\_POS} \end{cases}$$

2 Reference solution

2.1 Method of calculating

In the two modes of request, the membrane is in uniform stress state. One can thus analytically calculate the solution of this problem in both cases.

•Request of tension

In the case of a simple request of tension, one shows simply that, in the total reference:

$$\begin{cases} \varepsilon_{XX} = F_X \dfrac{M_{LLLL}}{\left(M_{TTTT} M_{LLLL} - M_{LLTT}^2\right)} \\ \varepsilon_{YY} = -F_X \dfrac{M_{LLTT}}{\left(M_{TTTT} M_{LLLL} - M_{LLTT}^2\right)} \\ \varepsilon_{XY} = 0 \end{cases}$$

•Request of shears

In the case of a request of shears, one shows that, in the total reference:

$$\begin{cases} \varepsilon_{XX} = 0 \\ \varepsilon_{YY} = 0 \\ \varepsilon_{XY} = \dfrac{\sigma_{XY}}{M_{LTLT}} \end{cases}$$

2.2 Quantities and results of reference

One tests displacement, the stress and the strain at the top $POINT$. The quantities tested are summarized in the table below, for the two modes of request.

Component	quantity	Tension simple	Shears	Tolerance
Displacement	DX	3/8	1/2	1.E-6
	DY	-1/8	1/2	1.E-6
membrane Strains (local coordinate system)	EXX	-1/8	0	1.E-6
	EYY	3/8	0	1.E-6
	EXY	0	$\sqrt{2}/2$	Forced
1.E-6 membrane (local coordinate system)	NXX	0	0	1.E-6
	NYY	1	0	1.E-6
	NXY	0	$\sqrt{2}$	1.E-6

3 Modelization A

3.1 Characteristic of the mesh

The modelization A is based on a mesh of 52 linear triangles (TRIA3).

4 Modelization B

4.1 Characteristic of the mesh

The modelization B is based on a mesh of 25 linear quadrangles (QUAD4).

5 Modelization C

5.1 Characteristic of the mesh

The modelization C is based on a mesh of 52 quadratic triangles (TRIA6).

6 Modelization D

6.1 Characteristic of the mesh

The modelization C is based on a mesh of 25 quadratic quadrangles (QUAD8).

7 Summary of the results

This test validates the behavior of an anisotropic membrane, as well as the computation of the membrane strains and the membrane stresses.