SSLS504 - Composite square plate made up of 3 layers, subjected to a loading doubly sinusoidal

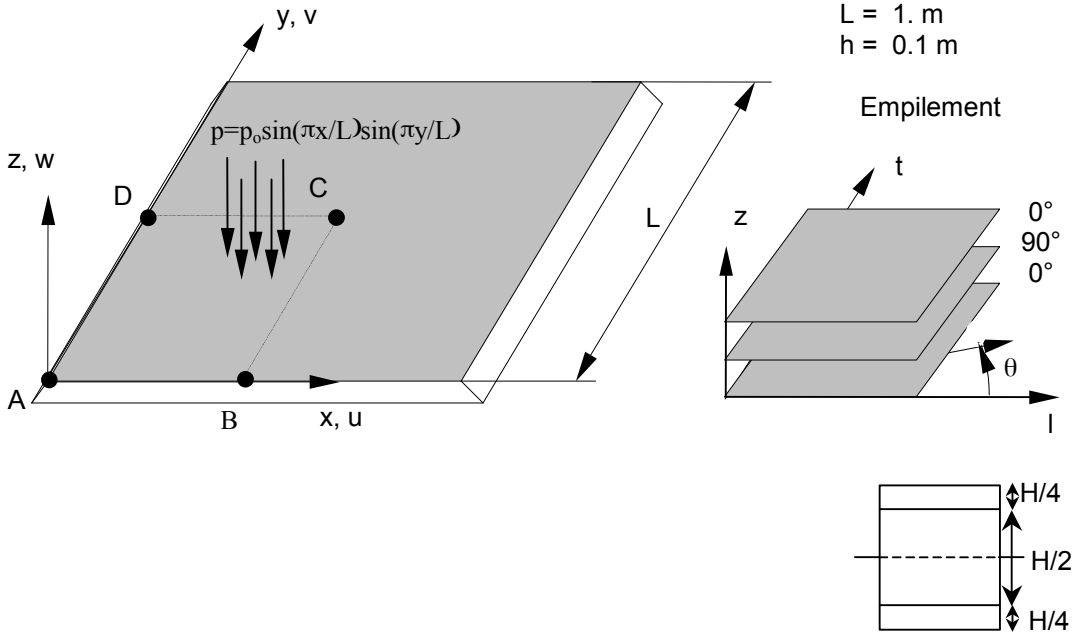
Summary:

This test represents the quasi-static calculation of a composite square plate made up by 3 layers, simply supported, subjected to a doubly sinusoidal loading. This CAS-test makes it possible to validate modeling finite elements DST with the meshs TRIA3 and QUAD4, frontmulti-layer EC a composite material.

Displacements and the constraints obtained are compared with a digital reference solution.

1 Problem of reference

1.1 Geometry



The 3 layers have as a relative thickness: $H/4, H/2, H/4$

1.2 Properties of material

The axes of orthotropism correspond to the curvilinear directions x and y .

$E_l = 25.$ $E_t = 1.$ ($l \Leftrightarrow x$; $t \Leftrightarrow y$)
$G_{lt} = G_{lz} = 0.5$ $G_{tz} = 0.2$
$\nu_{lt} = 0.25$

1.3 Boundary conditions and loadings

- Boundary conditions: displacement perpendicular to the plate, to its contour is null.
- Loading: $p = p_o \sin(\pi x/L)\sin(\pi y/L)$ with $p_o = 0.01$

1.4 Initial conditions

Without object

2 Reference solution

2.1 Method of calculating used for the reference solution

The reference solution is a digital solution [3].

2.2 Results of reference

The digital results of reference are the following:

Size					DST* (TRIA3)	DST* (QUAD4)
• Displacement w	at the point	C	$(L/2, L/2, 0)$		– 0.07323	– 0.07417
• Constraint σ_{xx}	at the point	C	$(L/2, L/2, h/2)$	(layer 3)	– 0,478	– 0,482
• Constraint σ_{yy}	at the point	C	$(L/2, L/2, h/4)$	(layer 2)	– 0,339	– 0.4
• Constraint τ_{xz}	at the point	D	$(0, L/2, 0)$	(layer 2)	– 0.0203	– 0.0305
• Constraint τ_{yz}	at the point	B	$(L/2, 0, 0)$	(layer 2)	– 0.0406	– 0.0204

* the reference solutions were obtained with a grid 6×6 [3].

2.3 Uncertainties on the solution

Lower than 2%

2.4 Bibliographical references

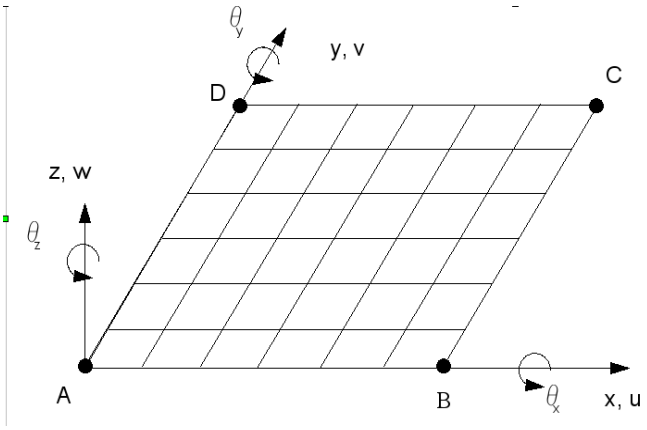
1) BATOZ J.L., DHATT G.: Modeling of the structures by finite elements, Flight 2, Beams and Plates, HERMES.

2) PAGANO N.J., Hatfield J.J. : “Elastic behaviour of multilayered bidirectional composite”, AIAA J., Flight 10, N°7, p. 931-933, 1972.

3) LARDEUR P.: Development and evaluation of two new finite elements of plates and composite hulls with influence of transverse shearing, Doctorate Engineer, University of Technology of Compiegne, 1990.

3 Modeling A

3.1 Characteristics of modeling



Modeling DST (QUAD4)

Boundary conditions:
Side AB : $w=\theta_y=0$
Side AD : $w=\theta_x=0$

Conditions of symmetry:
Side BC : $u=\theta_y=0$
Side CD : $v=\theta_x=0$

3.2 Characteristics of the grid

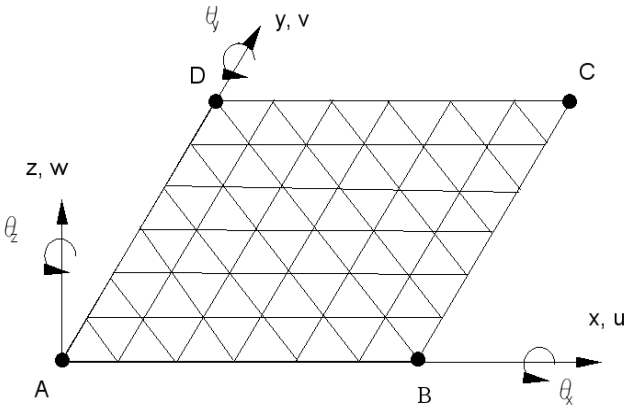
Many nodes: 49
Number of meshs and type: 36 QUAD4

3.3 Sizes tested and results

Identification	Type of Reference	Value of reference	Tolerance
Displacement w at the point C $(L/2, L/2, 0)$	'SOURCE_EXTERNE'	– 0.07417	0.4%
Constraint σ_{xx} at the point C $(L/2, L/2, h/2)$	'SOURCE_EXTERNE'	– 0,482	2%
Constraint σ_{yy} at the point C $(L/2, L/2, h/4)$	'SOURCE_EXTERNE'	– 0,400	4%
Constraint τ_{xz} at the point D $(0, L/2, 0)$	'SOURCE_EXTERNE'	– 0.0305	2%
Constraint τ_{yz} at the point B $(L/2, 0, 0)$	'SOURCE_EXTERNE'	– 0.0204	3%

4 Modeling B

4.1 Characteristics of modeling



Modeling DST (TRIA3)

Boundary conditions:
Side AB : $w=\theta_y=0$
Side AD : $w=\theta_x=0$

Conditions of symmetry:
Side BC : $u=\theta_y=0$
Side CD : $v=\theta_x=0$

4.2 Characteristics of the grid

Many nodes: 49
Number of meshs and type: 72 TRIA3

4.3 Sizes tested and results

Identification	Type of Reference	Value of reference	Tolerance
Displacement w at the point C $(L/2,L/2,0)$	'SOURCE_EXTERNE'	– 0.07323	3%
Constraint σ_{xx} at the point C $(L/2,L/2,h/2)$	'SOURCE_EXTERNE'	– 0,478	4%
Constraint σ_{yy} at the point C $(L/2,L/2,h/4)$	'SOURCE_EXTERNE'	– 0,339	6.5%
Constraint τ_{xz} at the point D $(0,L/2,0)$	'SOURCE_EXTERNE'	– 0.0203	12%
Constraint τ_{yz} at the point B $(L/2,0,0)$	'SOURCE_EXTERNE'	– 0.0406	12%

5 Summary of the results

- **Displacements** : the result got with the meshs QUAD4 is satisfactory (variation of 0.4%). One observes a more important variation (3%) for the meshs TRIA3.

- **Constraints** : the result got with the meshs QUAD4 is satisfactory (maximum change of 3%). One observes a more important variation (7%) for the meshs TRIA3.

This test thus makes it possible to validate the calculation of the composite plates under loading function of the geometry, as well in term of displacements as of constraints.