

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

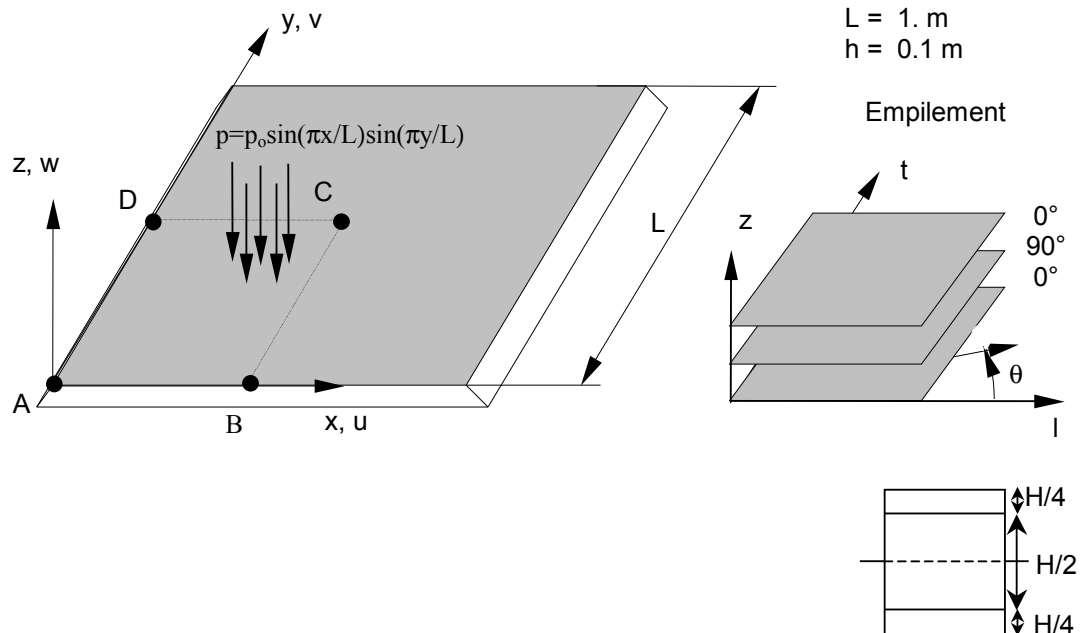
Abstract:

This test represents the quasi-static computation of a composite square plate made up by 3 layers, simply supported, subjected to a doubly sinusoidal loading. This benchmark makes it possible to validate the modelization finite elements DST with meshes the TRIA3 and QUAD4, a composite multi-layer.

Displacements and the forced obtained are compared with a numerical 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 the material

the axes of orthotropy correspond to the curvilinear directions x and y .

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

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 Reference solution

2 object

2.1 Method of calculating used for the reference solution

the reference solution is a numerical solution [3].

2.2 Results of reference

the numerical results of reference are the following:

Quantity		DST* (TRIA3)	DST* (QUAD4)
• Displacement w	at the point C $(L/2, L/2, 0)$	- 0.07323	- 0.07417
• Stress σ_{xx}	at the point C $(L/2, L/2, h/2)$ (layer 3)	- 0.478	- 0.482
• Stress σ_{yy}	at the point C $(L/2, L/2, h/4)$ (layer 2)	- 0.339	- 0.4
• Stress τ_{xz}	at the point D $(0, L/2, 0)$ (layer 2)	- 0.0203	- 0.0305
• Stress τ_{yz}	at the point B $(L/2, 0, 0)$ (layer 2)	- 0.0406	- the 0.0204

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

2.3 Uncertainties on the solution

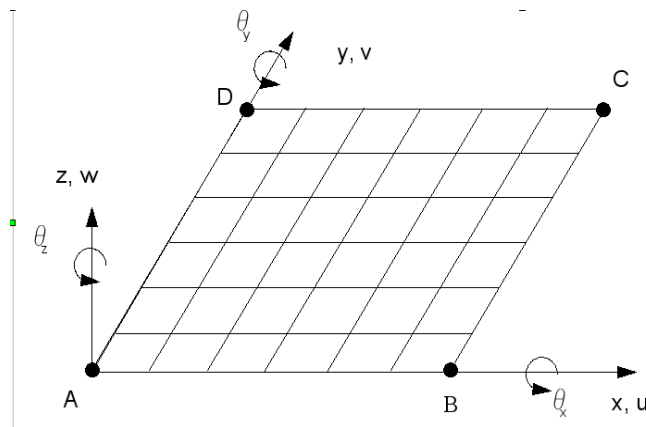
Lower than 2%

2.4 bibliographical References

- 1) BATOZ J.L., DHATT G.: Modelization of structures by finite elements, Flight 2, Beams and Plates, HERMES.
- 2) PAGANO N.J., Hatfield J.J. : "Elastic behavior of multilayered bidirectional composite", AIAA J., Flight 10, N°7, p. 931-933, 1972.
- 3) LARDEUR P.: Development and evaluating of two new finite elements of plates and composite shells with influence of the transverse shears, Doctorate Engineer, University of Technology of Compiègne, 1990.

3 Modelization A

3.1 Characteristic of the modelization



Modelization 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 mesh

Many nodes: 49

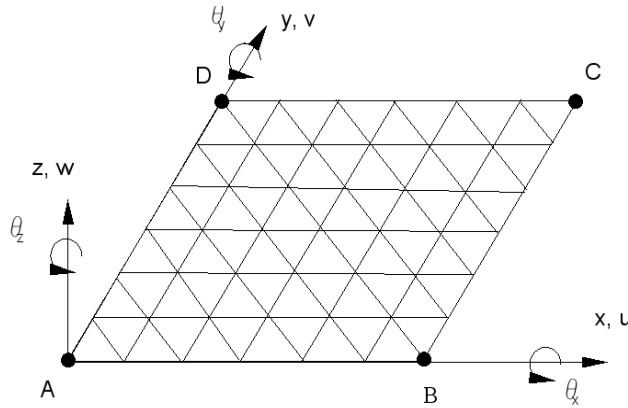
Number of meshes and type: 36 QUAD4

3.3 Quantities tested and Standard

	Identification	results of Reference	Value of reference	Tolerance
Displacement	w to point C $(L/2, L/2, 0)$	"SOURCE_EXTERNE"	- 0.07417	0.4%
Stress	σ_{xx} at point C $(L/2, L/2, h/2)$	"SOURCE_EXTERNE"	- 0.482	2%
Stress	σ_{yy} to point C $(L/2, L/2, h/4)$	"SOURCE_EXTERNE"	- 0.400	4%
Stress	τ_{xz} at point D $(0, L/2, 0)$	"SOURCE_EXTERNE"	- 0.0305	2%
Stress	τ_{yz} to point B $(L/2, 0, 0)$	"SOURCE_EXTERNE"	- 0.0204	3%

4 Modelization B

4.1 Characteristic of the modelization



Modelization 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 mesh

Many nodes: 49

Number of meshes and type: 72 TRIA3

4.3 Quantities tested and Standard

	Identification	results of Reference	Value of reference	Tolerance
Displacement w	to point C $(L/2, L/2, 0)$	"SOURCE_EXTERNE"	- 0.07323	3%
Stress σ_{xx}	at point C $(L/2, L/2, h/2)$	"SOURCE_EXTERNE"	- 0.478	4%
Stress σ_{yy}	to point C $(L/2, L/2, h/4)$	"SOURCE_EXTERNE"	- 0.339	6.5%
Stress τ_{xz}	at point D $(0, L/2, 0)$	"SOURCE_EXTERNE"	- 0.0203	12%
Stress τ_{yz}	to point B $(L/2, 0, 0)$	"SOURCE_EXTERNE"	- 0.0406	12%

5 Summary of the Displacements

- **results** : result obtained with meshes the QUAD4 is satisfactory (variation of 0.4%). One observes a more important variation (3%) for meshes the TRIA3.
- **Stresses** : result obtained with meshes the QUAD4 is satisfactory (maximum change of 3%). One observes a more important variation (7%) for meshes the TRIA3.

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