SSLS117 - Offsetting of plates nonsymmetrical

Summary:

This test validates the offsetting of nonsymmetrical simple plates compared to the plan of the grid or plan of diagram (keyword OFFSETTING order AFFE_CARA_ELEM).

The reference is given by a first resolution where one models double-layered made up of two layers various thicknesses and two materials.

It is used to validate the second calculation where one models two layers offset compared to the plan of the grid.

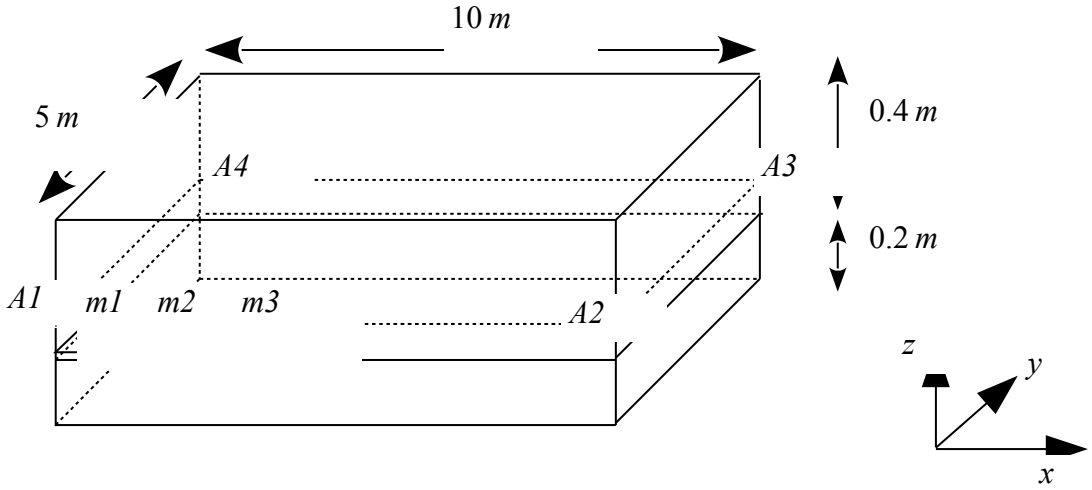
It differs from the test SSLS111 only by the fact that the 2 layers are different thicknesses.

Four modelings implement the elements DKT, DKQ, DST, DSQ.

One highlights on the double-layered case the difference between modelings, due to the effect of shearing transverse.

1 Problem of reference

1.1 Geometry



1.2 Properties of materials

1.2.1 Modelings A and B

The material has an isotropic elastic behavior:

Young modulus: $E = 20000\,MPa$

Poisson's ratio: $\nu = 0.$

Density: $\rho = 1000\,kg/m^3$

1.2.2 Modelings C and D

The material is double-layered.

The material constituting the first layer is elastic orthotropic and is characterized by the following data:

$E_L = 20000\,MPa$ $E_T = 20000\,MPa$ $\nu_{LT} = 0.3$ $G_{LT} = 2000\,MPa$

The material constituting the second layer is also elastic orthotropic and is characterized by the following data:

$E_L = 15000\,MPa$ $E_T = 15000\,MPa$ $\nu_{LT} = 0.3$ $G_{LT} = 1500\,MPa$

1.3 Boundary conditions and loadings

1.3.1 Modelings A and B

The edge $A1A4$ is embedded.

A force distributed is applied $F_z = -1000\,N/m$ on the edge $A2A3$.

1.3.2 Modelings C and D

The node $A1$ is embedded $DX=DY=DZ=0.$

$$DRX=DRY=DRZ=0.$$

The node $A2$ is blocked according to the following degrees of freedom: $DX=DY=0.$

The nodal forces are applied $FZ=-1000\,N$ on the node $A3$, and one applies the loading distributed (keyword FORCE_COQUE) on the meshs $m1$, $m2$ and $m3$:

$FX=200\,N$ $FX=-500.\,N/m^2$ $FZ=-500.\,N/m^2$ $MX=100.\,N/m$ $MY=40.\,N/m$

The selected loading utilizes requests out of membrane and inflection.

2 Reference solution

2.1 Method of calculating used for the reference solution

Calculation with double-layered material (order DEFI_COMPOSITE) is used as reference. Nonthe regression compared to the results got by this first calculation is checked. The two plates of the second modeling are offset compared to the average plan of the double-layered one.

2.2 Results of reference

2.2.1 Modelings A and B

They are made up by the values of the field of displacement DZ with not $A3$ and of the efforts generalized with the node $A1$. In addition, the 4 smaller frequencies of the structure are calculated.

2.2.2 Modeling C and D

They are made up by the values of the field of displacement DX , DY , DZ , DRX , DRY at the point $A3$ and at the point $A4$.

One compares also the efforts generalized with the node $A1$.

In addition, the 4 smaller frequencies of the structure are calculated.

2.3 Uncertainty on the solution

For modelings A and B , the reference solution is analytical. There is thus no uncertainty.

For modelings C and D , uncertainties are Nulles since it is about the same calculation carried out by two different ways.

2.4 Bibliographical references

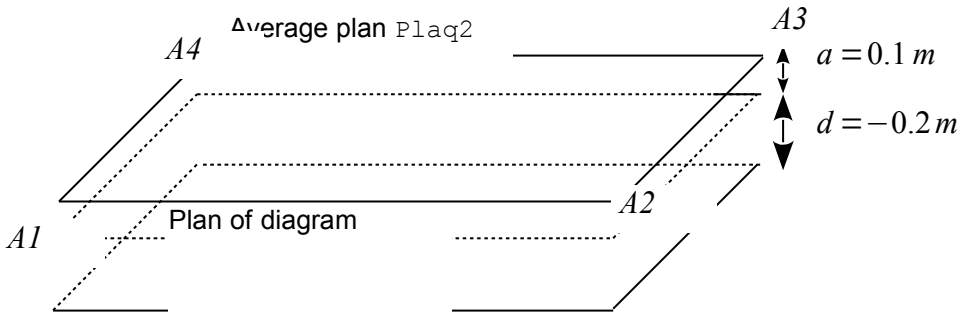
1) [R3.07.03]: Elements of plate DKT, DST, DKQ, DSQ and Q4G.

2) [R3.07.06]: Treatment of offsetting for the elements of plate DKT, DST, DKQ, DSQ and Q4G.

3 Modeling A

3.1 Characteristics of modeling

The model consists of two plates corresponding to the average plan of each of the two layers of the model of reference. To represent these two plates, one leaves the grid of the plan of diagram which one offsets distances $0.1\,m$ and $-0.2\,m$.



The elements used are elements of plate DKT.

3.2 Characteristics of the grid

Coordinates of the nodes:

Node	X	Y	Z
$A1 = N65$	0.	0.	0.
$A2 = N66$	10.	0.	0.
$A3 = N1$	10.	5.	0.
$A4 = N51$	0.	5.	0.

- 94 nodes; GROUP_MA : $L14 = A1A4$, $L12 = A2A3$
- 100 meshs DKT (TRIA3).

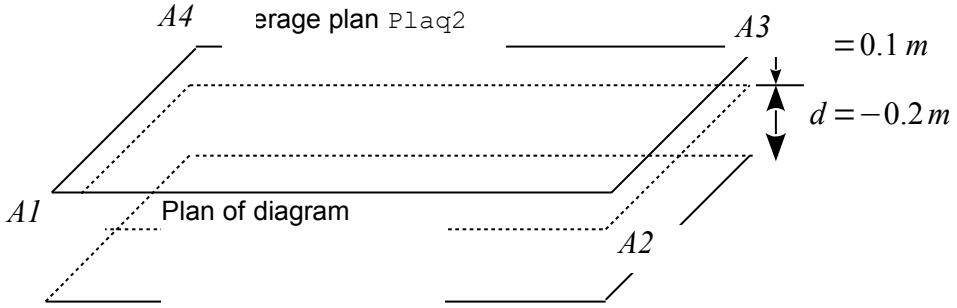
3.3 Sizes tested and results

Identification	Type of reference	Reference	Tolerance (%)
Displacement			
DZ ($A3$)	'ANALYTICAL'	-9.259259 10^{-5}	0.5
Eigen frequencies			
Frequency 1 er mode	'NON_REGRESSION'	13.67	0.1
Frequency 2ème mode	'NON_REGRESSION'	64.86	0.1
Frequency 3ème mode	'NON_REGRESSION'	84.47	0.1
Frequency 4ème mode	'NON_REGRESSION'	101.16	0.1
Generalized efforts			
MXX $N66$	'ANALYTICAL'	5000.	0.1
QX $N66$	'ANALYTICAL'	– 500.	0.1

4 Modeling B

4.1 Characteristics of modeling

The model consists of two plates corresponding to the average plan of each of the two layers of the model of reference. To represent these two plates, one leaves the grid of the plan of diagram which one offsets distances $0.1\,m$ and $-0.2\,m$.



The elements used are elements of plate DKQ.

4.2 Characteristics of the grid

Coordinates of the nodes:

Node	X	Y	Z
$A1$	0.	0.	0.
$A2$	10.	0.	0.
$A3$	10.	5.	0.
$A4$	0.	5.	0.

- 67 nodes
- 50 meshs DKQ (QUAD4)

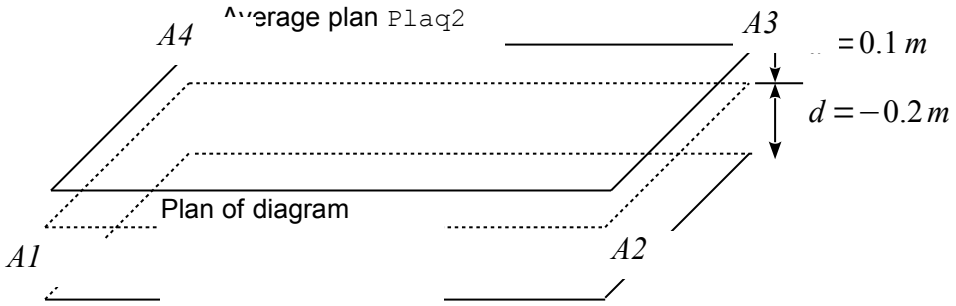
4.3 Sizes tested and results

Identification	Type of Reference	Reference	Tolerance (%)
Displacement			
DZ ($A3$)	'ANALYTICAL'	-9.259259 10^{-5}	0.5
Eigen frequencies			
Frequency 1er mode	'NON_REGRESSION'	13.7	0.1
Frequency 2ème mode	'NON_REGRESSION'	66.65	0.1
Frequency 3ème mode	'NON_REGRESSION'	85.49	0.1
Frequency 4ème mode	'NON_REGRESSION'	100.1	0.1
Generalized efforts			
MXX $N60$	'ANALYTICAL'	5000.	0.1
QX $N60$	'ANALYTICAL'	– 500.	0.1

5 Modeling C

5.1 Characteristics of modeling

The model consists of two plates corresponding to the average plan of each of the two layers of the model of reference. To represent these two plates, one leaves the grid of the plan of diagram which one offsets distances $0.1\,m$ and $-0.2\,m$.



The elements used are elements of plate DST.

5.2 Characteristics of the grid

Coordinates of the nodes:

Node	X	Y	Z
$A1=N1$	0.	0.	0.
$A2=N11$	10.	0.	0.
$A3=N65$	10.	5.	0.
$A4=N66$	0.	5.	0.

- 66 Nodes
- 100 meshs DST (TRIA3)

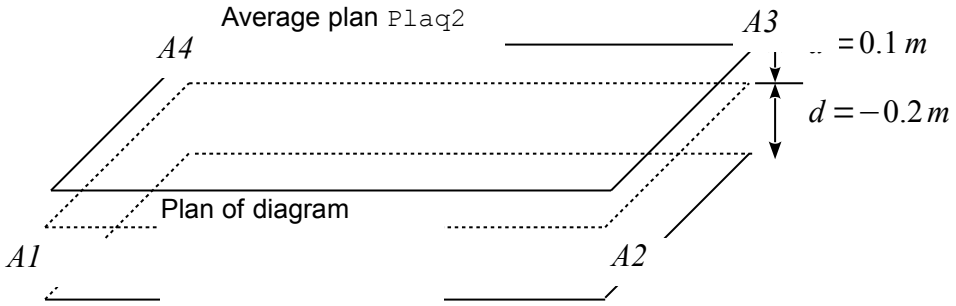
5.3 Sizes tested and results

Identification	Type of Reference	Reference	Tolerance (%)
Displacement			
DX ($A4$)	'NON_REGRESSION'	– 1,939 10^{-6}	0.1
DY ($A4$)	'NON_REGRESSION'	– 1,149 10^{-6}	0.1
DZ ($A4$)	'NON_REGRESSION'	– 2.2091 10^{-4}	0.6
DRX ($A4$)	'NON_REGRESSION'	– 6.09302 10^{-5}	0.6
DRY MARTINI ($A4$)	'NON_REGRESSION'	1.297279 10^{-4}	0.4
DX ($A3$)	'NON_REGRESSION'	– 2.4385 10^{-6}	0.1
DY ($A3$)	'NON_REGRESSION'	– 2.3382 10^{-7}	0.5
DZ ($A3$)	'NON_REGRESSION'	– 1.5864 10^{-3}	0.4
DRX ($A3$)	'NON_REGRESSION'	– 1.2639 10^{-4}	0.3
DRY MARTINI ($A3$)	'NON_REGRESSION'	1.4127 10^{-4}	0.4
Eigen frequencies			
Frequency 1er mode	'NON_REGRESSION'	1.512356	0.1
Frequency 2ème mode	'NON_REGRESSION'	6.373398	0.1
Frequency 3ème mode	'NON_REGRESSION'	1.25011 10^{1}	0.1
Frequency 4ème mode	'NON_REGRESSION'	2.546726 10^{1}	0.1
Generalized efforts			
NXX $A1$	'NON_REGRESSION'	9.85902 E+03	0.3
NYY $A1$	'NON_REGRESSION'	6.36055 E+03	0.5
NXY $A1$	'NON_REGRESSION'	2.07601 E+03	1.5
MXX $A1$	'NON_REGRESSION'	2.11639 E+04	0.5
MYY $A1$	'NON_REGRESSION'	1.49410 E+04	0.5
MXY $A1$	'NON_REGRESSION'	5.82623 E+03	0.65
QX $A1$	'NON_REGRESSION'	– 2.56538 E+03	0.6
QY $A1$	'NON_REGRESSION'	1.79286 E+03	1.5

6 Modeling D

6.1 Characteristics of modeling

The model consists of two plates corresponding to the average plan of each of the two layers of the model of reference. To represent these two plates, one leaves the grid of the plan of diagram which one offsets distances $0.1\,m$ and $-0.2\,m$.



The elements used are elements of plate DSQ.

6.2 Characteristics of the grid

Coordinates of the nodes:

Node	X	Y	Z
$A1=N1$	0.	0.	0.
$A2=N51$	10.	0.	0.
$A3=N65$	10.	5.	0.
$A4=N66$	0.	5.	0.

- 67 nodes
- 50 meshs DSQ (QUAD4)

6.3 Sizes tested and results

Identification	Type of reference	*Reference*	Tolerance (%)
Displacement			
DX (*A4*)	'NON_REGRESSION'	– 2.34539 10^{-6}	0.1
DY (*A4*)	'NON_REGRESSION'	– 1.9694 10^{-6}	0.1
DZ (*A4*)	'NON_REGRESSION'	– 2.2428 10^{-4}	0.1
DRX (*A4*)	'NON_REGRESSION'	– 6.2983 10^{-5}	0.1
DRY MARTINI (*A4*)	'NON_REGRESSION'	1.5823 10^{-4}	0.1
DX (*A3*)	'NON_REGRESSION'	– 3.0023 10^{-6}	0.1
DY (*A3*)	'NON_REGRESSION'	– 4.6612 10^{-7}	0.1
DZ (*A3*)	'NON_REGRESSION'	– 1.8842 10^{-3}	0.1
DRX (*A3*)	'NON_REGRESSION'	– 1.2768 10^{-4}	0.1
DRY MARTINI (*A3*)	'NON_REGRESSION'	1.7064 10^{-4}	0.1
Eigen frequencies			
Frequency 1er mode	'NON_REGRESSION'	1.4219	0.1
Frequency 2ème mode	'NON_REGRESSION'	5.2995	0.1
Frequency 3ème mode	'NON_REGRESSION'	1,215 10^{1}	0.1
Frequency 4ème mode	'NON_REGRESSION'	2.4385 10^{1}	0.1
Generalized efforts			
NXX *A1*	'NON_REGRESSION'	8.68372 E+03	0.1
NYY *A1*	'NON_REGRESSION'	– 4.10693 E+03	0.1
NXY *A1*	'NON_REGRESSION'	3.90190 E+02	0.1
MXX *A1*	'NON_REGRESSION'	3.47663 E+04	0.1
MYY *A1*	'NON_REGRESSION'	1.52451 E+04	0.1
MXY *A1*	'NON_REGRESSION'	6.34489 E+03	0.1
QX *A1*	'NON_REGRESSION'	– 1.70439 E+04	0.1
QY *A1*	'NON_REGRESSION'	– 9.82819 E+03	0.1

7 Summary of the results

With regard to displacements for modelings DKT and DKQ, the results got with 2 offset hulls differ from to the more 2% compared to the reference solution. For other modelings, one obtains to the maximum of the errors of 4% for DST and 6% for DSQ. For these two last modelings, the error is more important because the calculation of transverse shearing is not equivalent between the double-layered one and the two offset plates.

Indeed, transverse shearing is supposed to be constant in the thickness of each element DST or DSQ ; this transverse shearing is an average shearing. One thus obtains a median value for each plate offset, overall different from average transverse shearing on the double-layered plate.

This is marked even more for the efforts, where the differences remain lower than 5% for modelings DKT (With and B) but 11% for modeling reach C and 100% for modeling D.

One can thus note that for DSQ, 2 calculations (double-layered and full-course offset) are far from being equivalent. One preserves nevertheless this modeling precisely to display this difference.